http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 3, Vol. 6 November 2017–January 2018

Field Trip to Randolph-Macon College Keeble Observatory

By Jerry Hubbell and Linda Billard

On December 2, Matt Scott, Jean Benson, Bart and Linda Billard, Jerry Hubbell, and Peter Orlowski joined Scott Lansdale to tour the new Keeble Observatory at his alma mater, Randolph-Macon College in Ashland, VA. The Observatory is a cornerstone instrument in the College's academic minor program in astrophysics and is also used for student and faculty research projects.

At the kind invitation of Physics Professor George Spagna—Scott's advisor during his college days and now the director of the new facility—we received a private group tour. We stayed until after dark to see some of its capabilities.

Keeble Observatory at Randolph-Macon College Credit: Jerry Hubbell

R-C Observatory Telescope Credit: Jerry Hubbell

The observatory, constructed in summer 2017, is connected to the northeast corner of the Copley Science Center on campus. It houses a state-of-the-art $30,000 Astro Systeme Austria (ASA) Ritchey-Chretien telescope with a 16-inch (40-cm) primary mirror. Instrumentation will eventually include CCD cameras for astrophotography and scientific imaging, and automation for the 12-foot (3.6-m) dome. The mount is a $50,000 ASA DDM 160 Direct Drive system placed on an interesting offset pier system that allows the mount to track well past the meridian without having to do the pier-flip that standard German equatorial mounts (GEMs) perform when approaching the meridian. All told, the fully outfitted observatory will be equipped with about $100,000 of instrumentation and equipment.

During our visit, the sky was initially overcast but—as if on command—it cleared as the Sun went down. Professor Spagna and three of his students demonstrated the telescope by initially slewing to and showing us Albireo, or β Cygni—a bright pair of stars that shine red and blue. It was a glorious sight in the eyepiece. Using the freeware program Cartes du Ciel, which we also use in the MSRO, Professor Spagna slewed the telescope to a couple of other bright stars and Messier objects, including M31 Andromeda Galaxy, M57 the Ring Nebula, and M45 the Pleiades (Seven Sisters). Our tour ended a short time after twilight, and we enjoyed a delicious dinner at the Trackside Grill in Ashland.

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 closest to the new 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. We also have a Facebook presence.

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November 2017–January 2018
Published Quarterly by Rappahannock Astronomy Club
Editor: Linda Billard

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

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Myron Wasiuta Mark Slade Remote Observatory (MSRO)

Calendar of Upcoming Events

Star Party, Caledon State Park	February 17
STEAM Event, Stafford Elem School	February 22
Star Party, Caledon State Park	March 17*
Star Party, Caledon State Park	April 14*
Star Party, Caledon State Park	May 5*

Recent Outreach Events Completed

Star Party, Caledon State Park	November 11
Presentation, Park Ridge Elem School (Stafford)	December 15
Star Party, Caledon State Park	December 16
Presentation, Park Ridge Elem School (Stafford)	December 18
Star Party, Caledon State Park	January 20

*A program will precede these star parties. For topics, visit raclub.org prior to your visit.

President's Corner

Thanks to everyone for providing such great inputs to this month's newsletter—one of the best so far thanks to editor Linda Billard.

There was a great turnout at the January Star Party at Caledon State Park. I encourage everyone to come out and share the dark skies. Each time I am there, I get to see something new, better, and/or different from before. If the cold isn't for you, there will be plenty of opportunities once the weather warms up…soon, I promise. Please check the website for upcoming events and weather status.

Clear Skies, Scott Lansdale

Club News Briefs

- **NEXT CALEDON STAR PARTY:** Weather permitting, come on out to Caledon State Park on February 17 for our next star party.
- **RAC PUBLICITY CARD:** Thanks to the efforts of Payel Patel, Jerry Hubbell, and Linda Billard, the club now has a postcard-size card that members can use to provide information about the club to interested members of the public.
- **MINOR PLANET OBSERVATION:** Minor planet observations made by Jerry Hubbell in November using the MSRO were documented in the December 3 issue of the *Minor Planet Circulars.*

Astronomy Math: Relationship of Wavelength, Frequency, and Energy (cont'd) by Scott Busby

In the last newsletter, I talked about the relationship of wavelength, frequency, and energy. I continue on that subject and ask you to recall the equation we used relating wavelength and frequency:

$$\lambda = c/f \text{ or } f = c/\lambda \text{ or } \lambda f = c$$

You can use this equation to calculate either the wavelength (λ) or frequency (*f*) of any light wave, given the other.

Example: The visible portion of the electromagnetic spectrum is centered near a wavelength of 500 nm (1 nm = 10^{-9} m). What is the frequency of these waves?

Choose the version of the equation that solves for frequency and plug in 500 x 10^{-9} m for λ and 3 x 10^{8} m/s for *c*:

$$f = c/\lambda$$

$$= \frac{3 \text{ x } 10^8 \text{ x } \cancel{m}/s}{500 \text{ x } 10^{-9} \cancel{m}}$$

$$= \frac{3 \text{ x } 10^8 \text{ x } \cancel{m}/\cancel{s}}{5 \text{ x } 10^{-7} \cancel{m}} \frac{1}{s} = \frac{3}{5} \text{ x } 10^{8+7} \text{ Hz}$$

$$= 0.6 \text{ x } 10^{15} \text{ Hz} = 6 \text{ x } 10^{14} \text{ Hz}$$

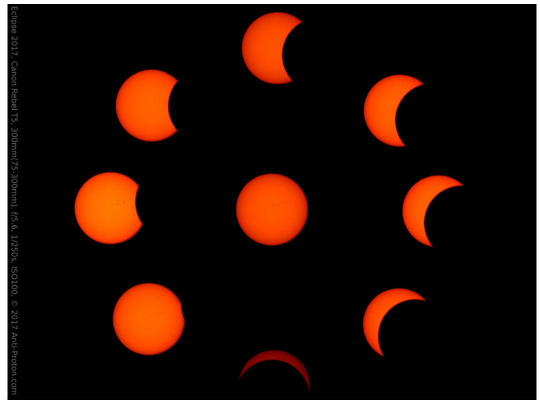
Note that although the units of meters cancel, seconds is retained in the denominator, so meters *per* second (m/s) becomes simply *per* second (1/s), or hertz. We emphasize the word "per" because many folks drop the fraction bar that represents "per" in that step, so their units erroneously come out in seconds—which is not a unit of frequency.

Because the frequencies of electromagnetic waves are typically very large numbers in hertz (especially in the visible range and above), they are often preceded by metric prefixes. Thus you're very likely to see frequencies expressed with units of kilohertz (kHz or 1,000 Hz), megahertz (MHz or 10^{6} Hz), gigahertz (GHz or 10^{9} Hz), and terahertz (THz, or 10^{12} Hz). Wavelengths, on the other hand, are often very small, so you will often find them expressed with smaller metric prefixes such as millimeters (mm, or 10^{-3} m), micrometers or "microns" (μm, or 10^{-6} m), and nanometers (nm, or 10^{-9} m). Although not a metric unit, the angstrom (Å, or 10^{-10} m) is also commonly used to express wavelengths.

Solar Secondary Atmospheric X-Ray Analysis of 2017 Eclipse

By Tom Watson

Was it possible to detect a change in secondary solar x-ray radiation during the 2017 North American solar eclipse?



August 2017 Eclipse, Caledon State Park Credit: Tom Watson

The solar eclipse of 2017 covered a significant percentage of the North American continent and adjacent lands, in varying degrees of darkness, as the Moon eclipsed the Sun. During an eclipse, light emitted by the Sun is blocked by the Moon. Can the same be said for other particle emissions from the Sun to such a degree that they can be measured on Earth? You should understand that the Sun blankets the Earth in protons, alpha particles, x-rays, and other energetic particles. While our eyes are accustomed to measuring photons (visible light), many other particles interact with our atmosphere creating secondary x-rays that can be detected on the ground.

Materials and Methods

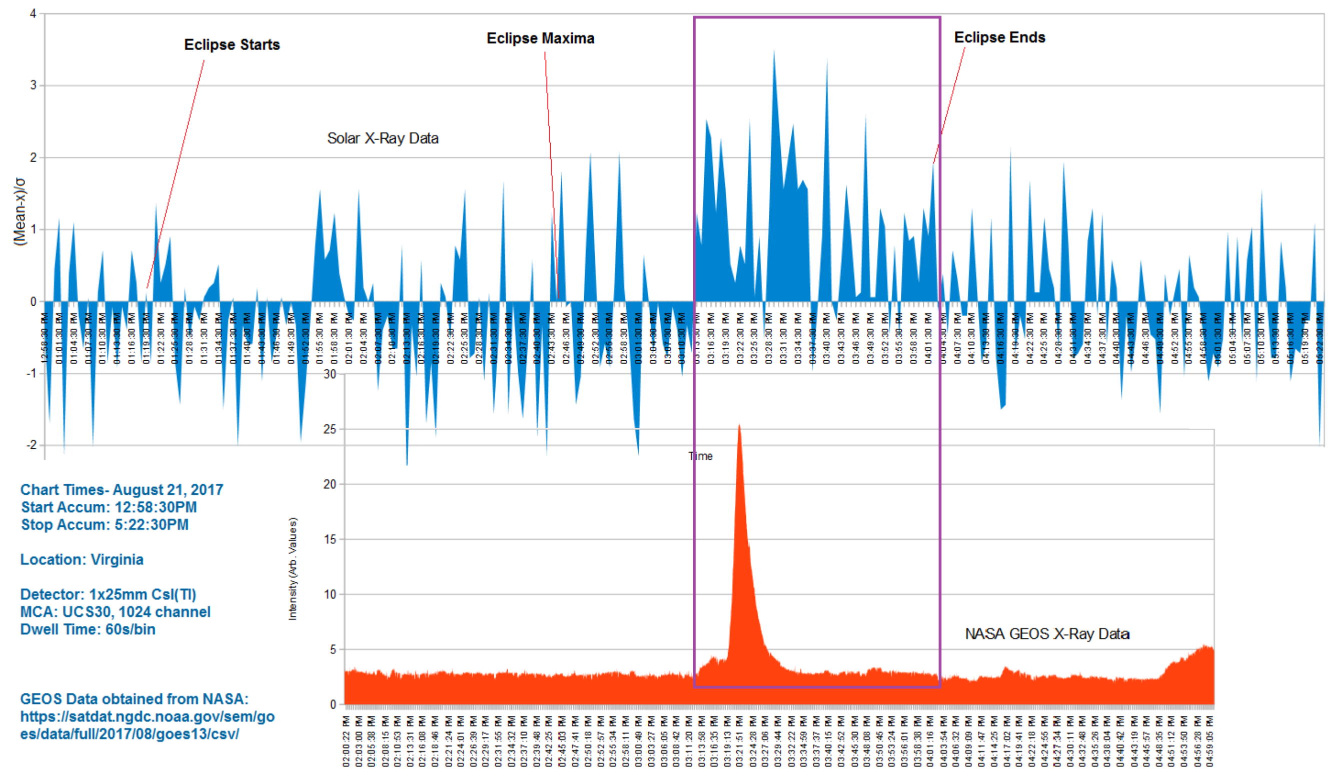
The primary detector I used was an SE International RAP47 thin crystal x-ray scintillation probe. This probe detector is made from a single cesium iodide, thallium-doped, commonly denoted CsI(TI), crystal. The crystal is coin shaped, with a thickness of 1 mm and a diameter of 25 mm. This scintillation probe was powered by and its data were recorded by a Spectrum Techniques UCS30 multichannel spectrum analyzer with 1,024 data-gathering channels and a voltage driver.

I put the detector on a plastic table on the second floor of my house, which is primarily wood. The detector was shielded from beneath by 25 mm of lead, as well as 3–10 mm of lead above and around. Between the lead and the detector, a 1-mm copper and a 1-mm plastic layer provided shielding against secondary x-rays made by the interaction of high-energy particles and the shielding itself (commonly called Z graded shielding). The purpose of the shielding was to reduce the incidence of naturally occurring radioactive material (NORM), which produce false x-ray readings not attributed to extraterrestrial sources.

I configured the x-ray scintillator to record a maximum of 1,024 individual measurements, each spanning a period of 60 seconds, all contiguous. The detector was initiated at 02:19:30 a.m. August 21, Eastern Standard Time, and allowed to run without interruption until 05:23:30 p.m. the same day. The actual eclipse began at 1:19 p.m., peaked at 2:44 p.m., and ended at 4:03 p.m. local time. I left the detector unsupervised during this time.

Results

My analysis of the data recorded during the eclipse indicates no major change in solar radiation during the eclipse, although an unexpected solar flare was detected at the end of the eclipse. An increase in x-ray flux detected by the x-ray detector occurred at a period after the zenith of the eclipse, but before the partial eclipse ended. This increase of x-ray flux corresponded with a solar x-ray flux increase detected by the NASA GEOS satellite (National Centers for Environmental Information. NASA. August 21, 2017). The x-ray flux detected by the x-ray detector returned to a nominal level at approximately the same time as the GEOS satellite detected a return of solar x-ray activity to nominal.



Terrestrial x-ray flux during the period of the solar eclipse Credit: Tom Watson

The result indicates probable inferential detection of solar particles by detecting the secondary x-rays emitted by the atmosphere when primary solar flare particles strike the upper atmosphere. Taking the mean of the GEOS data from 02:00:02 p.m. until 04:59:59 p.m., roughly the 3 hours surrounding the eclipse, I calculated a population mean of 3.34, in arbitrary units, with a standard deviation of 2.59, also in the same arbitrary units. The x-ray signal increases above the mean from 03:13:43 p.m. until 03:31:04 p.m. (considering only rises above the mean for three consecutive time samplings). The terrestrial x-ray detector began detecting an increase above its population mean at 03:13:30 p.m., continuing until 03:36:30 p.m., considering four contiguous readings above the mean.

Discussion

The actual likelihood of detecting a change in solar radiation as a result of the occultation of the Sun using a small terrestrial x-ray detector was unknown at the beginning of the experiment.

The peaks detected by GEOS did not correspond directly to the peaks detected by the x-ray detector, although this may have been a result of the nature of terrestrial secondary x-ray detection. The x-rays detected from the Sun move faster than the more massive charged particles that strike the atmosphere causing much of the x-ray production that is detected. When an x-ray flare occurs, an increased period of x-ray detection can be expected, but they do not always coincide, although they are proximate.

Acknowledgments

NASA GEOS

References

National Centers for Environmental Information. NASA. August 21, 2017. Accessed online January 10, 2018, at https://satdat.ngdc.noaa.gov/sem/goes/data/full/2017/08/goes13/csv/

Acquiring a Takahashi FRC300 and Associated Experiences

By Scott Busby

Takahashi Flat-Field Ritchey-Chretien 300 (FRC300)
Credit: Scott Busby

Linda Billard asked me to write an article about my newest telescope acquisition—the Takahashi Flat-Field Ritchey-Chretien 300 (FRC300). Let me begin by saying that I rarely buy anything astronomy related brand new. I always look for deals in the usual "astronomy for sale" Internet websites I frequent, and seldom visit any retail outlets—online or otherwise. Because most high-quality telescopes and accessories are quite expensive, I am reasonably confident that whomever I buy something pre-owned from took good care of it.

Seasoned amateur astronomers tend to seek something more capable than what they currently own in terms of telescopes or added capability in terms of accessories. An example would be the purchase of larger aperture optics or eyepieces, or, if one is interested in astrophotography, a more modern camera or high-quality computerized equatorial mount.

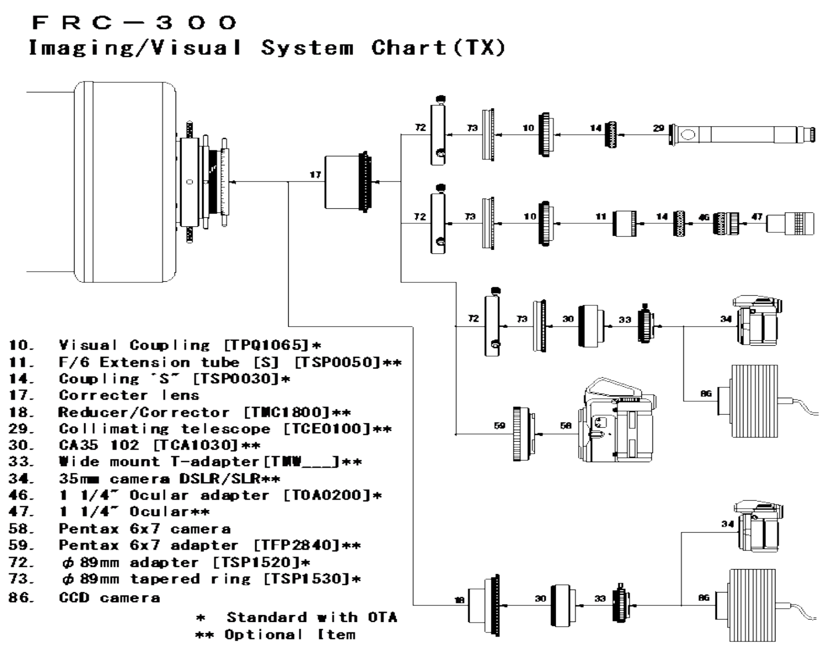
In the case of the Takahashi FRC300, it was simply one of those happenstance opportunities that occurred during my online browsing. I really wasn't looking to improve on what I already owned, i.e., the Mewlon 250 (10-inch) Cassegrain reflector, which is a beautifully made telescope and one that I was completely satisfied with. Nevertheless, a deal appeared that I couldn't resist and that I could afford.

The Takahashi FRC300 is primarily an astrograph, i.e., it is optimized for astrophotography and has significant limitations for visual observing. The optical system is a corrected flat-field Ritchey-Chretien at 300 mm diameter or about 11.8 inches; the secondary is 125 mm; the native focal ratio is f7.8 at 2,348 mm focal length, producing a 90 mm image circle; the reduced focal ratio is f5.9 at 1,770 mm, producing a 36mm image circle. The OTA is 40.55 inches long, 12.76 inches in diameter; the bare tube weighs 66 pounds. My current mount, the EM400 has a maximum weight capacity of 77 pounds. So, I have about 11.6 pounds to play with for cameras, guidescopes, and other accessories. However, it is my understanding that Takahashi typically underrates the true capacity of its equatorial mounts. My EM400 is mounted atop a Pier-Tech 2 mechanical pier, which has a max capacity of 215 pounds. Yes she's heavy, but it remains within my capability.

The original owner purchased this particular FRC300 in 2004. Takahashi has since discontinued the FRC design in favor of the BRC250 and Mewlon 300 telescopes. What is unique about the FRC is its helical focuser. Advantages of the helical focuser are its fine adjusting range and ability to remain locked at focus without any drift whatsoever. The disadvantages are it is extremely difficult to find the focused sweet spot and any accessory like a camera rotates as you focus. Fortunately, the FRC is equipped with a camera rotator ring allowing good positioning.

The original owner, who lives in Massachusetts, was kind enough to deliver the telescope in person, saving significant shipping costs. Unfortunately for me, because of work obligations and overcast skies (which inevitably occur with the purchase of a new telescope) it was nearly 3 months before I was able to get the scope mounted in the observatory. It was another month before first light.

As with any new instrument, there were quirks to be worked out. Balancing of the scope was first priority to achieve smooth tracking. First light came after I had to purchase some additional adapters to allow for visual viewing. My initial impression was “WOW”! The additional light-gathering capability was readily apparent in visual mode. Yes, I identified the need to tweak collimation, and I needed a special Takahashi collimation scope to achieve perfect collimation. Fortunately, I already had said scope at hand—I had purchased years before for the Mewlon 250. I discovered it wouldn’t work for the 250, so it stayed shelved until the FRC arrived!



It is important to tell you right now that Takahashi doesn’t make anything ready to go out of the box. There is always the inevitable need for some Tak accessory to make your new telescope completely operational. Takahashi doesn’t share any of this information with you, and the only US authorized distributor isn’t knowledgeable enough to tell you what you need for your particular application. After discussion with the previous owner and careful examination of the FRC system charts, I was able to identify the necessary adapters for visual use and astrophotography for my particular cameras. Yes, there was additional expense acquiring the necessary adapters, and if there is anything well known about Takahashi products, it is their exorbitant prices.

I’ve had the FRC since March 2017. I’ve worked out all the particulars in getting it up and running with success and I hope you are enjoying the images I submit to the RAC Group website and via email to the RAC.

M51 Whirlpool Galaxy taken @ Belmont Observatory January 2018 Credit: Scott Busby

Orion Magnificent Mini AutoGuider—A Review

By Tom Watson

What Is Autoguiding?

Because the Earth rotates once every 24 hours, the stars appear to slowly move overhead during the night. While this apparent rotation is hard to detect with the human eye in real time, when you observe stars at higher magnifications than the human eye sees, this motion becomes noticeable. The apparent movement of stars within the field of view of the observer increases as the magnification of the star increases. Not only can this be problematic for extended viewing through a telescope eyepiece, but it can also become extremely troublesome for astrophotography.

Telescope connected to auto guider Credit: Tom Watson

During the photography of a star or astronomical body through a lens or telescope, the tiniest motion of a star can cause a blur in the final photo. Unguided photography is possible if you use a mount that is specially designed to follow the motion of the Earth (such as a German Equatorial Mount). A motor drives this rotation on the mount and extremely good calibration of the mount so that its movement matches the rotation of the Earth. However, your efforts are generally limited to exposure lengths less than 30 seconds (although this depends on many factors, including the focal length of the lens or telescope).

Photo of left was taken without autoguiding. Photo on right was taken with autoguiding Credit: Tom Watson

The solution is autoguiding. Using a camera, the autoguider samples the stars every few seconds, calculates the slight difference between the telescope or camera mount movement and the actual stars' apparent movement, and then feeds tiny adjustments to the motors, which drive the mount for a telescope or camera. This process adjusts for the slight inaccuracies that would otherwise cause blur in the final picture. Autoguiders typically involve a telescopic lens connected to a camera, which connects either directly to the mount or to a computer, depending on whether the circuitry that calculates the adjustments is embedded within the camera or within a computer.

Orion Magnificent Mini AutoGuider

One of the major drawbacks to autoguiding has been the price. Autoguiding solutions require a motorized mount, a camera, a smaller telescope used to feed the camera imagery, and software. Even if these concerns are met, there is the problem of weight. Adding a second telescope and camera can significantly increase the payload a mount must carry, a concern for many people, depending on their equipment's capabilities. The Orion Magnificent Mini AutoGuider solves this problem by attaching a lightweight camera to a wide-angle finder scope, as opposed to a full-size telescope. The weight and cost are further reduced by using a laptop computer to perform the calculations. Laptops are often expensive, but they are also widely owned and have many uses outside of astronomy.

The Orion autoguider kit comes with a small finder scope with an aperture of 50 mm and a focal length of 162 mm (f/3.2). This finder scope has an all-metal design with a glass lens and fits conveniently onto most telescope finder scope mounts. The optical tube weighs 1.3 lbs, making the entire guiding solution less than 2 lbs when fully mounted. A camera is included that fits directly to the back of the finder scope and provides a 1.3-megapixel monochrome image. While this camera can actually be used for primary imaging, and a full-color version of this camera also exists, monochrome is quite effective for autoguiding. All of the required cables are included.

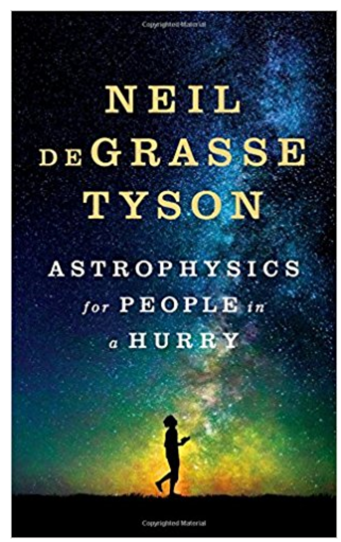
To use the unit during the day, connect the camera to the autoguider and point the unit at a target off in the distance to focus, such as a full Moon during the day. At night, you set up your mount and telescope as normal, aligning them as you usually would. Select an object in the sky to observe and then connect your autoguider camera's USB cable to your laptop. Tracking is controlled by PHP software, which you can download freely from the Internet. The controls are straightforward to use, and within a few minutes, you will be locked onto a star and autoguiding. Important to consider is that the initial calibration phase of the unit, which PHP does for you automatically, may take several minutes. During this time, it is not advisable to use the telescope because any slight movement can destroy your calibration requiring you to recalibrate.

I have found this autoguider to be perhaps the most useful tool I have ever bought for astrophotography. Previously, my ability to take photographs was limited to exposures of 8 to 30 seconds. A 30-second exposure could take me as long as an hour of manual calibration to perfectly align the movement of my mount with the rotation of the Earth. Now, within about 5 to 10 minutes of setting up my equipment, I can effortlessly take 60- to 120-second exposures. The difference between a 30- and a 120-second exposure is the difference between a single point of light showing a star, and beautiful nebulosity floating around the star. Rich colors not perceptible in a 30-second exposure burst out of the image at 60 and 120 seconds.

Summary	
Pros	**Cons**
A complete and fully functional, easy-to-use system for about $350. No exotic items to purchase or complex knowledge to acquire.	Manual focus by adjusting the depth that the camera is inserted into the back of the finder scope. This can be quite cumbersome, although once you have a proper focus, you need not adjust it.
Able to guide scopes up to 1,500 mm in focal length.	Cable management is a bit of a problem and can affect photography if the cables are not properly taped or connected to the mount to prevent them from moving in the wind or simply creating drag on the motor.
Depending on your mounting calibration and the quality of your equipment, exposure length could easily exceed 300 seconds, and tracking for repeated photos on an object will remain approximately stable for the entire night.	The unit requires a laptop to function. While this is not a problem for backyard photography, where an extension cord can give you unlimited laptop life, it can be a major concern during remote observation. Further, cold weather reduces battery life for most laptops. While you may have 8 hours of summer battery life, that may translate to 1.5 hours in the winter.

Book Review: *Astrophysics for People in a Hurry,* by Neil de Grasse Tyson

By Bart Billard



Of authors who write on astronomy and astrophysics for a more general audience, one of my favorites is Neil de Grasse Tyson. His *Astrophysics for People in a Hurry* is a short book that came out last year. I read it about 6 weeks ago after Linda and I had listened to the audiobook version (read by him and occasionally interrupted by messages from the car GPS—"Traffic Jam Ahead") on a trip to the Outer Banks last November. It is a compilation of "Universe" essays in *Natural History Magazine* that appeared between March 1997 and April 2007. The essays have been adapted and updated to form chapters that narrate the story of our current knowledge of astrophysics and cosmology. I was not at all disappointed.

To refresh my memory for this review, I tried rereading a few selected chapters as stand-alone essays (like someone in enough of a hurry to pick and choose topics). One of the updates to the original essays was the inclusion of the topic of the first successful observation of gravitational waves by the Laser Interferometer Gravitational-wave Observatory (LIGO) in chapter 6 on dark energy. In the very entertaining first passage of the chapter, Tyson calls dark energy "one of the most mind-warping ideas of twentieth-century physics" and adds that you can "just blame Einstein." This introduction leads to the topic of Einstein's theory of General Relativity ("GR" if you're in a hurry) and his addition, then removal, of a "cosmological constant," written Λ, in the equation. The chapter is about the eventual return of Λ as a result of the 1998 announcement of research using more precise observations of distance to remote galaxies based on apparent brightness of certain supernovae, which showed the expansion of the universe is accelerating.

Tyson notes that removing Λ was effectively the same as setting it equal to zero, and the new results on supernovae observations amount to measurements testing GR to show Λ is *not* zero. The recent 2016 LIGO observation story fits well in the chapter as another example of continued testing of GR. It is worth reading the first 4+ pages of the chapter just for Tyson's punchline. (I'm leaving the spoiler out of this review.) If you are in a hurry, you should be able to read this or some other chapter at random to decide whether you are going to enjoy reading the whole book.

Focus On: Mons and Montes (Mountains and Mountain Ranges)

By Jerry Hubbell

(Note from the author: A version of this article was published in the January 2018 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)*

This article continues a discussion of the different types of lunar features with mons and montes. When I got my first telescope during the Apollo era of lunar exploration, the Moon was the object of choice to observe. Two of my favorite objects were the isolated peaks Piton and Pico near the crater Plato. These two peaks reminded me of the drawings of Chesley Bonestell with the jagged lunar peaks and breathtaking vistas of the Moon. Early lunar cartographers depicted the peaks as jagged because of the stark shadows (Figure 1). This first impression set the stage for centuries of awesome views of the lunar landscape, which until the 1960s, was not fully understood.

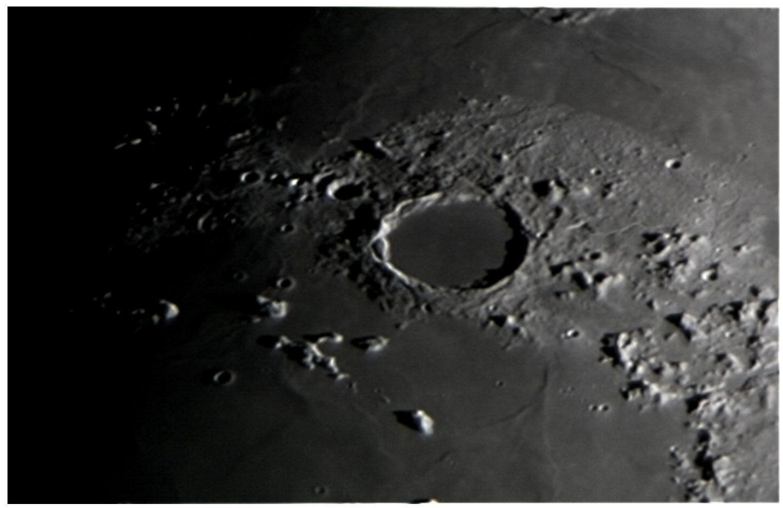


Figure 1. Mons Pico near Plato, Francisco Alsina Cardinalli, Oro Verde, Argentina, December 20, 2015 0206 UT, 250 mm. Schmidt-Cassegrain (Meade LX 200), Canon Eos Digital Rebel XS, north/up, east/right.

Several ALPO members provided extensive descriptions and images of various mountains and mountain ranges, demonstrating the depth of knowledge and skill our observers bring to the table. Most notable are David Teske and members of the Lunar Group of the Madrid Amateur Astronomical Society (AAM). The following are excerpts from their contributions, which are greatly appreciated.

David Teske

Figure 2. Montes Caucasus, David Teske, Louisville, Mississippi, USA, 26 November 2017 at 0134 UT. Colongitude 356.6 degrees, Seeing 6/10, 4 inch APO refractor.

Montes Caucasus: These mountains mark the western boundary of Mare Serenitatis and the eastern boundary of Mare Imbrium. This heavily eroded, rugged mountain range is a direct continuation of the Apennines, separated from the latter by a flat, lava-covered strait approximately 50 km wide. Montes Caucasus is likely made of Imbrium ejecta. Stretching 520 km, this battered old range is generally 3 to 4 km tall but also contains some of the highest peaks on the lunar near side, towering 6 km above the lunar surface. If one could stand on one of these peaks, one could see for 140 km. The Montes Caucasus is not arcuate toward either the center of Imbrium or Serenitatis.

Montes Apenninus: This is the greatest range of mountains on the lunar nearside. These mountains serve as the southeastern rim of the Imbrium Basin. With a length of 600 km, the range includes 3,000 individual peaks; some, such as Mons Huygens, tower 5 km. The side facing Mare Imbrium is steep, with a slope of 30 degrees, whereas the other side (toward Mare Vaporum) is significantly less steep. The scarps are not continuous but are broken into a series of roughly parallel, but sometimes offset, massifs that are 25–50 km long. The hilly terrain of the Apennine back slope is cut by lineations that radiate from the Imbrium Basin. The Montes Apenninus originated 3.85 billion years ago when a giant impact forever changed the face of the Moon. This impacting projectile caused the highland crust along its southeastern border to be violently uplifted, forming this spectacular mountain range. Ejecta from this impact cover the Apennine highlands.

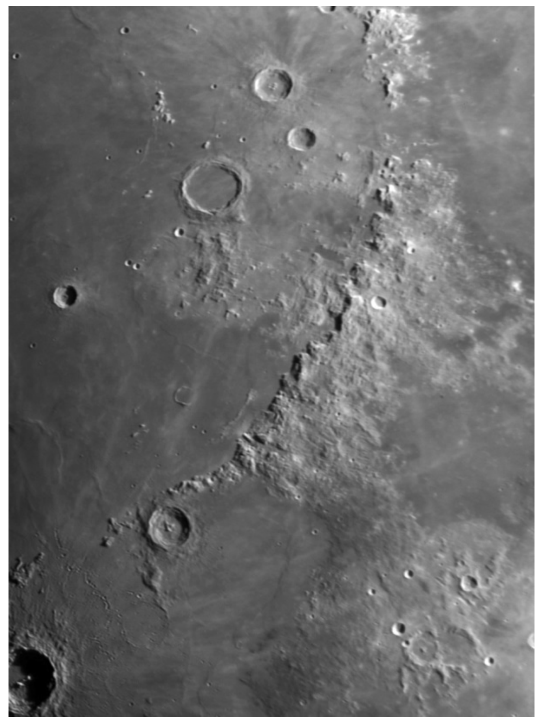


Figure 3. Montes Apenninus, David Teske, Louisville, Mississippi, USA, 28 November 2017 at 0224 UT. Colongitude 21.3 degrees, Seeing 5/10, 4-inch APO refractor.

Montes Agricola: This narrow, straight chain of mountains extends 160 km to the northwest of the Aristarchus Plateau, lying on the plains of Oceanus Procellarum. The Moon's narrowest mountain range must somehow be associated with the nearby Aristarchus Plateau. The range parallels the northern boundary of the Plateau and might also be associated with the formation of the Imbrium Basin. The northern portion of Montes Agricola runs, at a right angle, into the Moon's smallest named wrinkle ridge, Dorsum Niggli, which runs 50 km to its junction with the Aristarchus Plateau.

Lunar Group of the Madrid Amateur Astronomical Society (AAM)

Members of the AAM Lunar Group observed Montes Apenninus on November 26, 2017, under clear skies, moderate turbulence and light pollution, 40 km from Madrid, and in high drought (after 50 days of no rainfall). Visibility for the relevant Moon zone, position angle -23.2 degrees and libration in longitude, -8 degrees(!), conspired in their favor to take out of shadow most of the features they planned to observe. Average Sun altitude over Montes Apenninus was 5.6 degrees.

They used two telescopes—one 102 mm ED refractor and one 20 cm SC. After a couple of unsuccessful attempts, two 200-frame videos were captured with a QHY-III camera attached to the 102 mm refractor scope by a Barlow x2 lens, which were processed later with the Registax-6 program. Figure 4 shows the outcome image.

A close visual inspection with the SC scope at moderate power (200x) showed five razor-sharp peaks, casting very delicate individual shadows onto the Mare Imbrium dark surface—so delicate that the observers could identify some smaller peaks by looking at the shadows they cast. Unfortunately, the first two videos recorded at that time failed, so they did not catch this stirring and elusive scene. Despite the good viewing conditions, the extent of the shadow prevented seeing the Mons Wolf and Eratosthenes crater, both known to be located at the western end of the range. Even Montes Archimedes was out of sight.

Meanwhile as the shadow retracted, the group devoted its time to identifying the five peaks uncovered at that time. Mons Hadley, easily identified because of a shorter companion and because of its nearness to the small crater Santos-Dumont, was somehow brighter (it recalled a snowy mount) than the remaining peaks. Although it is known to be second in the height ranking (4,800 m), the double curvature of range and of the lunar floor, as well as the double shadow because of its lesser brother, pose a limitation on the ability to see it. North of Mons Hadley and just at the edge of the shadow, the group saw an elongated rocky outcrop and beyond it, Rimae Fresnel, a very thin system of grooves, difficult to notice in Figure 4, which carried lava during the basin lava fill epoch.

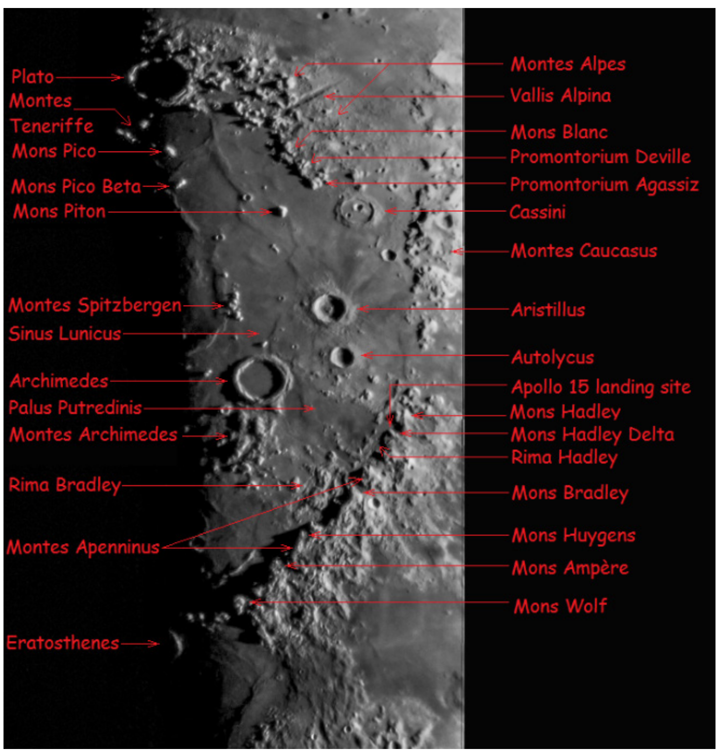


Figure 4. Montes Apenninus, Montes Caucasus, Montes Alpes and Montes Spitzbergen, as well as Mons Pico and Mons Piton.

Mons Hadley Delta, located due southwest of Mons Hadley and separated from it by an arcuate nook, cast a dark shadow on the floor, which prevented the group from observing Rima Hadley and the Apollo 15 landing site. Mons Hadley Delta is not as tall (3,500 m) as Mons Hadley and has a darker hue.

Mons Bradley is not next in the row, but fourth. Mount number three in the row currently has no name. Nevertheless, Mons Bradley is number three in height (4,200 m), and it is best identified by crater Conon, located ramp-down from the peak. (One must be cautious not to confuse the 22-km crater Conon with the smaller 10.6-km crater Aratus.) At the foot of Mons Bradley, the group could see the broad platform called the Apenninus bank that runs along the mountain range. Mons Bradley summit is very steep and has a bright facies. In the particular case of this observation, the shadow extent was not long enough to cover Rima Bradley, the very broad and sinuous groove located beyond the Apenninus bank that separates the whitish lava flood that runs all the way across to Montes Eratosthenes. Unfortunately, the bright hue of this special non-magmatic lava is only visible under high illumination conditions, and the group missed it.

Mons Huygens is not next in the row after Mons Bradley, but it is separated from it by a very long and dark nook and by another anonymous peak. It is best localized by looking for the west end of the

Apenninus bank, after the anonymous peak. So, Mons Huygens—number one in the height ranking (it towers 5,500 m)—is sixth along the range. Its summit is not steep, but rather chunky, and its west slope catches one's attention because of its soft tilt. At the time of the group's first observation, the Mount Huygens shadow lay very close to the terminator, so they were unable to identify the tip.

Mons Ampère rises beyond the Mons Huygens soft tilt ramp-down slope. Its 3,000-m height is the sixth (last) position in the height ranking, and its west slope is also soft. Because it was rather close to the terminator, the group could not see a great deal of detail in this first observation.

About 50 km north of Montes Apenninus lies Montes Caucasus, a mountain range whose loftiest ridge reaches a maximum height of 6,000 m. Despite this great height, the overall aspect of the range is quite different from that of Montes Apenninus. In the group's observation, everything looked old and worn, mainly because of the lack of shadows. With the Sun altitude over the main range below 15 degrees, the lack of shadows revealed a soft slope, as is usual for old mountains. Even the distorted craters Alexander and Calippus contributed to spread that impression.

A much better option to observe at that time was Montes Alpes and Mons Piton. Montes Alpes is a flat mountain range that closes the northern edge of the Imbrium Basin, isolated from Montes Caucasus by the Cassini crater. At an average of half the height of Montes Apenninus and therefore half as impressive, its most appealing feature is the beautiful fault, Vallis Alpina. Three peaks have names, one echoing the tallest peak of earthly Alps, Mons Blanc, which rises 3,600 m, and two rocky cliffs that lean over the Imbrium lavas—Promontorium Agassiz, 2,280 m, and Promontorium Deville, 1,300 m.

Because the whole mountain range casts a dark shadow over the lava surface, and because of the Moon position angle, all three elevations cast northward-skewed shadows, too close to the darkened "shore," the group could not discern their true height by means of their extent. Only the Mons Blanc shadow could be distinguished easily as a double arrowhead bearing northeast, long enough to guess its tall elevation. And the group could not see the very narrow rille that runs along Vallis Alpina, no matter how hard they tried it.

Regarding Mons Pico, it is well known that under low Sun, the aspect of this mount is rather deceiving. At 2,250 m high, but 25 km wide, its slope is nothing much (≈10 deg.). However, under the viewing conditions that the group had, it cast a very long and pointy shadow that stretched a very long distance across the Mare Imbrium surface—amazing to beginning observers (and sometimes to those already skilled). But what really caught the group's attention was its high albedo and whitish aspect under grazing light. (Sun altitude above Mons Piton was 7 degrees.) These two features characterize Mons Piton as an anorthositic structure rather than a volcanic one, as was thought long ago. Nowadays, it is very easy to follow part of the arc of the second inner ring of the basin: Mons Piton—Mons Pico—Montes Tenerife—Montes Recti. All of them are protruding ridges aligned along the ring.

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Highlights of Recent RAClub Presentations

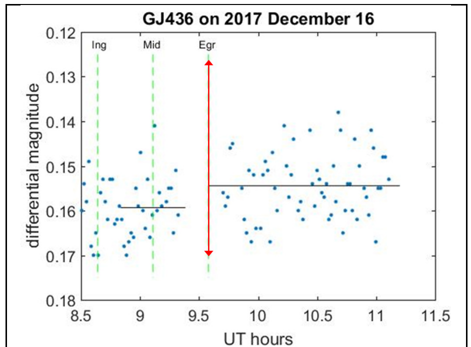
Abstracted from Bart Billard's Meeting Minutes
(Note: There was no program at the November meeting. RAC officer elections were held.)

December 2017—Exoplanet Transit Observation

Bart Billard and Jerry Hubbell began their presentation by talking about having taken a course for amateurs interested in observing the transits of extrasolar planets with orbits that pass between Earth and their host stars. The course was offered by the CHOICE program of the American Association of Variable Star Observers (AAVSO). Jerry showed the AAVSO website and the pages for the CHOICE courses, including the exoplanet observing course. He also showed where to find resources for exoplanet observing, including the website astrodennis.com maintained by Dennis Conti, the course instructor, whose book, *A Practical Guide to Exoplanet Observing*, is available for free download. Another website, Bruce Gary's Amateur Exoplanet Archive, provides a download link for his book, *Exoplanet Observing for Amateurs* (also available as a free PDF download—a small run of printed books has since sold out), and for a spreadsheet called BTE_ephemeris that Jerry and Bart used to predict transits for their early observing attempts.

Bart then described their recent observation using MSRO—a transit of the planet GJ436b, on December 16. The BTE_ephemeris spreadsheet showed a predicted transit with a star visual magnitude of 10.7 and a depth of 26 mmag (26 thousandths of a magnitude). Jerry and Bart thought the star brightness and relatively large transit depth were favorable for detecting with the MSRO 6-inch refractor. Bart explained the notation he had added next to prediction showing the star GJ436 was also called TYC 1984-2613-1 or HIP 57087. He put similar identifications alongside other predictions in the ephemeris using lookups in the Stellarium planetarium program, which indicated they came from Simbad. For GJ436, Stellarium found an identification not recognized by the Cartes du Ciel planetarium program on the MSRO computer. Bart showed how to look up the star directly on the Simbad website, where he found the TYC number that worked. The Cartes du Ciel view of the region of GJ436 and an image he and Jerry made to confirm whether they had found it with the telescope were not identical—there was a pair of stars in the Cartes du Ciel display but only one star in their image. Bart said it puzzled them as they prepared to observe the transit until they finally realized the program was displaying two different catalog positions for the same star. What looked like a convenient target and a well-matched reference star were actually just one object. Indeed, the identifier for the extra star in the program was the HIP number that Bart had added to the spreadsheet, and it was actually one of the identifiers that Simbad had found.

Jerry and Bart recorded the data that morning, with occasional cloudiness that produced some poor images. The results from the Maxim DL photometry analysis tool showed the calculated magnitudes of the target star and a reference star covering a period from 8.5 hours UT (3:30 a.m. EST) to a little after 11 hours UT. Both stars became dimmer during that time, and the cloudiness showed as some spotty and erratic extra dimming, especially between 9 and 10 hours UT. Unfortunately, some of the worst points were about the time that the dimming of the star by the exoplanet should have been decreasing up to the egress.



First light curve. Arrow indicates the 26 nmag prediction. Obviously the data are not consistent with such a prediction. What went wrong? Credit: Bart Billard

Bart noted that the MSRO Clear Sky Chart for that night showed transparency deteriorating by a step during the period he and Jerry were observing. Perhaps that trend accounted for the dimming of the two stars over the whole observation period. For the transit light curve, the differential magnitude (target star magnitude minus reference star magnitude) is plotted. This difference eliminates most of the intensity variation affecting both stars (for example, the effects of transparency), although some of the clouds' effects still showed through as more scattered and inconsistent measurements. The worst of these were discarded. The most striking thing about the light curve was that an arrow indicating the predicted depth of 26 mmag was nearly too long to fit the entire range plotted and was certainly not consistent with the measurements. A transit of that depth would have stood out clearly in the data. Bart explained that it led him to discover an error in the ephemeris spreadsheet that caused the prediction for a different exoplanet to appear for GJ436. When he looked at the tab devoted to their target star, he found the correct depth prediction was 7.5 mmag, not 26. The horizontal lines Bart included in the light curve plot representing the averages of the measurements near the middle of the transit and of those after the egress suggest the depth observed was about 5 mmag, which is more consistent with the prediction, given the uncertainties in the individual measurements.

Bart and Jerry said they were encouraged with the quality of the data they got even with the unfavorable conditions affecting much of their data. They identified ways they could be better prepared for the future attempts and learned there are two more up-to-date transit prediction resources they could use. Two of these are EDT (Exoplanet Transit Database) and NASA Exoplanet Archive. Bart said he and Jerry would definitely try more exoplanet observations. A PDF of the presentation is available on the club website on the monthly programs page.

Postscript: Bart and Jerry subsequently made a successful observation of HAT-P-30/WASP-51 b on January 4 to 5, 2018, and submitted their results to the Exoplanet Transit Database.

January 2018—Radiation from the Sun

Tom Watson began by talking about the different kinds of radiation, including particles, radio waves, light, x-rays, and gamma rays. Tom said another member had equipment for observing radio waves, but Tom was interested in radiation of higher energies. He said some radiation could not be detected on the ground and required having a satellite to get above the atmosphere. In fact, astronauts were exposed to radiation in space and sometimes saw flashes in their eyes from it.

Tom showed examples of some of his equipment in operation. He began with a gamma scintillator connected to a counter and turned them on to let us hear the amount of activity in the room. He said this activity was mainly from traces of uranium in the ground. He listed the kinds of solar and cosmic radiation he had recorded with his equipment:

- Solar wind, a stream of many particles spit out by the Sun. Tom said solar wind was hard for him to measure because it was so steady. He noted we might have seen pictures of the Earth's magnetic field being pushed and stretched out downstream by solar wind or read about the van Allen radiation belt containing particles from solar wind that are trapped in the magnetic field around the Earth.

- Particles from solar flares, which occasionally were sent out in our direction and caused magnetic disturbances and auroras.

- Coronal mass ejections (CMEs). The Sun has an atmosphere, and the corona is the outer part. Tom said that changes in the Sun's magnetic field were thought to eject mass from the corona occasionally.

- Cosmic rays, which Tom said were not rays but rather mostly protons, with other particles occasionally occurring. He talked about the high speeds, and hence energies of cosmic rays. He gave examples of observations of unstable particles and pointed out that they were so fast that time passed more slowly for them according to our clocks, allowing them to reach the detectors before they decayed. Tom also mentioned the "Oh-My-God particle" detected October 15, 1991, and described in *Wikipedia*. Its energy was 3×10^8 TeV, compared with about 13 TeV for particles in the Large Hadron Collider (a factor of more than 23 million larger). It traveled at about 99.9999999999999999999951 percent of the speed of light.

- Gamma ray bursts. Tom said he had hopes of detecting these even though NASA used satellites and the NASA scientists he had contacted were dubious that he might detect any on the ground. He said high-energy particles entering the atmosphere could cause showers of secondary particles and x-rays, which would be an indirect way of detecting the arrival of a burst of high-energy gamma ray photons. Tom demonstrated how the scintillator worked and how he connected it with a multichannel spectrum analyzer to get energy spectra of x-rays reaching the scintillator. The scintillator's sensitive element is a crystal that flashes when hit by an x-ray photon; the brightness of the flash is proportional to the energy of the photon. The scintillator tube contains a photomultiplier tube that converts the light flashes to electrical pulses with charge proportional to the brightness. The analyzer records the pulses, sorting them into bins corresponding to the brightness of the flash and counting the number of pulses for each bin. Tom connected the scintillator to the analyzer and displayed the resulting histogram of increasing counts in the different bins. To show the relation of bins to x-ray energy, Tom put his cesium-137 calibration source next to the scintillator tube, and counts began building up much faster in two groups of bins, producing peaks at those two locations, one near the left and one toward the right. One location corresponded to the x-ray energy of the cesium-137 and one to barium-137 (the decay product of the cesium-137). The locations of these signals allowed calibration of the energy spectrum of the x-rays hitting the scintillator.

Tom said his detector was located high in his house with 200 pounds of lead shielding under it, because he only wanted to detect radiation coming from the sky. He could detect energies from less than 5 KeV to about 5 MeV. He also had a detector for lower energies, and a couple of Geiger counters to help compensate for the lack of extra detectors to use for anti-coincidence logic. (For example, a Geiger counter under the lead shielding that detected a burst of radiation when the detectors above did not would indicate the burst was from a source other than the sky, such as a stress-test patient driving by.) To help confirm when he detected radiation from an astronomical source, Tom looked for a correlation with NASA data. He said he had seen big spikes correlated with coronal mass ejections detected by NASA's satellite at the L1 point.

Tom showed his recording for the time of the solar eclipse. There was some change, with more activity during the last third of the time the Moon crossed in front of the Sun. Some NASA GEOS x-ray data also showed some activity, somewhat similar, over that time period.

During his presentation, the spectrum of the calibration source had built up, and Tom was able to show the peaks from the cesium-137 and barium-137. The latter was sharper. He then demonstrated how he could set the analyzer to record a time series of counts within a selected energy range. For this demonstration, he chose 1 second as the time the analyzer would count for each bin before moving on to the next. This mode would record a peak corresponding to the time a burst of additional radiation was detected, which Tom demonstrated by briefly moving the calibration source near the scintillator. He ended by discussing a little more about what he thought his equipment could detect and the evidence he was successful. He related detecting x-rays, probably from an examining room at the dentist's office, while he was at the front desk paying his bill. He said although the NASA scientists were dubious that gamma ray bursts could be detected on the ground, some scientists have suggested a possibility of a gamma ray burst sterilizing life on Earth if it occurred close enough. That certainly suggests that something in between was possible. A PDF of the presentation is available on the club website on the monthly programs page.

Image of the Quarter

Horsehead Nebula Region: This spectacular "landscape" was taken by Myron Wasiuta early on the morning of November 23, 2017. It is a 3-hour exposure using MSRO with the Explore Scientific 102-mm FCD100 refractor. The camera used is the QHY 163 C (one-shot color), and the image is a stack of sixty 180-sec subs. Note that the telescope Myron used is the smaller of two housed in the main MSRO building.