http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 4, Vol. 6 February 2018–April 2018

Stephen Hawking: Black Hole Pioneer to Join Newton and Darwin

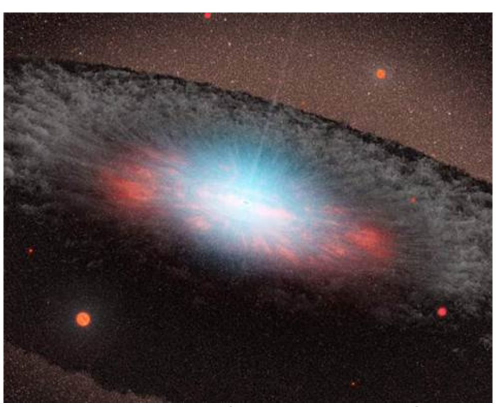
By Linda Billard

Source: www.digitaljournal.com

It's certainly fitting that Stephen Hawking will spend eternity with Sir Isaac Newton and Charles Darwin. Later this year, Hawking's ashes will be interred next to Newton at Westminster Abbey in London—the first scientist so honored in 80 years. He will join other remarkable contributors to science and the arts, including not only Newton and Darwin, but John Herschel, Ernest Rutherford, and J.J. Thomson. While this is a great honor, it raises the question: Why didn't Hawking win the Nobel Prize?

As you may (or may not) know, the restrictions on the Nobel Prize preclude posthumous awards, so it is now too late. But why didn't he win one earlier? The answer is fairly straightforward. According to Nobel rules, theoretical scientific discoveries must be confirmed by observational data before they can be considered for the prize. It often takes decades to build the scientific equipment to test theoretical discoveries. For example, Einstein's theory of gravitational waves in space, first proposed in the 1920s, was only recently proven in 2016—that's nearly 100 years!

One of Hawking's most noteworthy theories concerns the presence of something now referred to as Hawking radiation. The theory says that black holes are not completely black after all but emit radiations that ultimately cause them to disappear. Hawking proposed the existence of this radiation in 1974, but the technology needed to observe it and prove him correct will take years to develop and cost millions. This clip from a BBC documentary is a good layman's explanation of the Hawking radiation phenomenon.



Artist's rendering of a black hole. Source: NASA/JPL-Caltech/Tim Pyle (SSC)

So far, detecting Hawking radiation has been elusive because any trace of it is swamped by the cosmic microwave background. The temperature of the background radiation—energy left from the Big Bang—is about 2.7 kelvin, while the temperature of Hawking radiation is only 1.2 nanokelvin for a large black hole. There have been some recent attempts to create simulated black holes in the laboratory to test for the presence of Hawking radiation, but claims of success have been met with skepticism about the techniques used and thus the accuracy of the results. That said, Hawking continued to make contributions to physics and cosmology right up to his death. His last paper, "A Smooth Exit from Eternal Inflation?", co-authored with Thomas Hertog, a professor of theoretical physics at Leuven University, addresses the notion that our universe may be one of many and that the Big Bang wasn't the only one of its kind. The research, submitted 2 weeks before he died, presents the mathematics needed for a space probe to find experimental evidence for the existence of a "multiverse." If such evidence had been found while he was alive, it might have put Hawking in line for the Nobel Prize. However, even if evidence is found to support the theories postulated in this final paper, only Hawking's co-author could win for this work. "This was Stephen: to boldly go where Star Trek fears to tread," co-author Hertog told the London Times. "He has often been nominated for the Nobel and should have won it. Now he never can."

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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Calendar of Upcoming Events

Star Party, Caledon State Park	May 5*
Star Party, Caledon State Park	June 9*
Star Party, Caledon State Park	July 7*

Recent Outreach Events Completed

STEAM Event, Stafford Elem School	February 22
Star Party, Caledon State Park	March 17
Star Party, Caledon State Park	April 14
Astronomy Night, Anthony Burns Elem. School	April 19

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

President's Corner

Welcome to the April edition of the RAC newsletter. As always I like to focus on outreach events and where you might see us around town peering through telescopes in the dark. The box to the right highlights a couple but I'd also like to mention our last Star Party at Caledon State Park. About 6 members were in attendance and a number of visitors; 15 or more. The evening began with a presentation by Glenn Holliday about Oumuamua and wrapped up late with great observing. We observed nearly 20 celestial objects, and Tom Watson demoed astrophotography. Overall it was a great night, and I encourage all to come out. It's really more than just observing…it's a social event and a place to learn—even for us members.

Clear Skies, Scott Lansdale

Club News Briefs

- **NEXT CALEDON STAR PARTY:** Weather permitting, come on out to Caledon State Park on May 5 for our next star party.
- **ASTRONOMY NIGHT:** David Abbou participated in the Anthony Burns ES Astronomy Night on April 19. About 150 people attended. He and several others showed views of the crescent Moon to many adults and children who had never seen the Moon through a telescope before.

Astronomy Math: Relationship of Wavelength, Frequency, and Energy (part 3) by Scott Busby

In addition to finding the wavelength of an electromagnetic wave for which you know the frequency and vice versa, you may also want to find the energy of the photons of that wave. As I mentioned in the last newsletter, the energy of a photon is directly proportional to the photon's frequency, and the constant of proportionality is Planck's constant (h = 6.626 x 10-34 J s). The unit J stands for joules, the SI unit for energy. Thus the equation for converting between frequency and photon energy is:

$$E = hf$$

So, we want to find the energy in a photon with $\lambda = 500nm$. To find the energy, you can plug the values for *h* and *f* (found in last newsletter example), remembering that the unit Hz is the same as s^{-1}:

$$E = hf = (6.626 \times 10^{-34}\text{ J s})\ (0.6 \times 10^{15}\text{ 1/s}) = 3.98 \times 10^{-19}\text{ J}$$

You may find yourself wondering "If energy is related to frequency, and frequency is related to wavelength, how is energy related to wavelength?" You can answer that question by referring to the analogy of waving your arm and remembering that a larger energy corresponded to a higher frequency—waving your arm up and down faster while walking at the same speed. The arm-waving analogy also illustrates the inverse relationship between wavelength and frequency because the distance covered between successive waves of your arm—imagine dropping a pebble on the floor with each wave and measuring the distance between pebbles—decreases as your waving frequency increases. So as you wave your arm more furiously (higher frequency and higher energy), the distance between the pebble drops (wavelengths) decreases. Thus you can expect that energy and wavelength should be *inversely* proportional: $E \propto 1/\lambda$. Combining the last two equations (The one above and the one in the last newsletter) bears this out:

$$E = hf = h\,(c/\lambda) = hc/\lambda$$

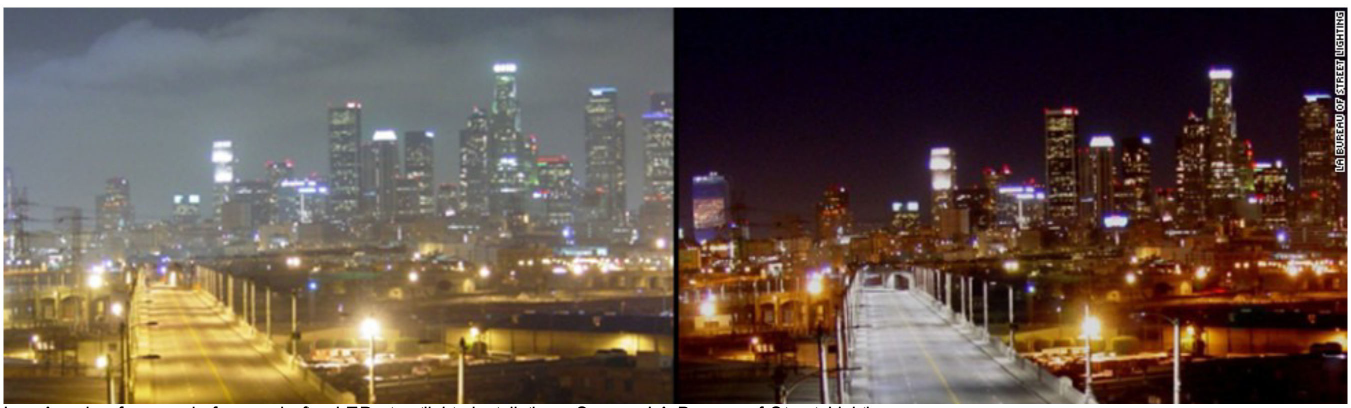
Because the wavelength is in the denominator on the right side of this equation, longer wavelength corresponds to lower energy, and shorter wavelength corresponds to higher energy.

LEDs and Light Pollution

Contributed by Scott Busby, courtesy of Jon Groubert (edited from his post on the "Telescope Addicts" Facebook page; photos added)

The International Dark-Sky Association (IDA) is a terrific organization, promoting awareness about how human activity is causing dark skies to recede all over the developed world and what we can do to reverse that trend. Recently, IDA's Dr. John Barentine gave a talk in which he stated that in a few years, as municipalities complete switching out their street lamps to light emitting diodes (LEDs), light pollution reduction (LPR) filters will become useless. This is because LEDs give off light across the entire visible spectrum, as opposed to mercury vapor or sodium vapor lamps (the bluish and yellowish street lights we all grew up with), which give off their light in just a narrow slice of the spectrum. These narrow slices of spectrum are what the LPR filters are designed to block. With their full spectrum light, LEDs cannot be blocked or filtered.

Dr. Barentine went on to say that there is a filter that would effectively block the blue and violet end of the LED's spectrum. It would do two things. First, it would shift the spectrum to make the LED light more yellowish and much less harsh on the eyes. But more important for astronomy, cutting out the blue end would mean that the light from LEDs would cause significantly less light pollution. This is because the atmosphere is most effective in scattering the blue wavelengths of light, which is exactly why the sky is blue. Cutting off the blue end of the LED spectrum would reduce the extent of that scattering and thereby reduce the impact from the LEDs. Unfortunately, these filters cost money, and the whole reason that municipalities are making the switch is to save money, not spend it on filters to please a few astronomers.



Los Angeles freeway before and after LED streetlight installation. Source: LA Bureau of Street Lighting, https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/msslc_la2012_ebrahimian.pdf

So, if your community has made the switch, is in the middle of making the switch, or is about to make the switch, LPR filters are about to become obsolete and relegated to the shelf of unused telescope accessories. However, if your community does not have plans to switch over, you might buy one of these filters now and hope to get a 2 or 3 years' use out of it before the inevitable switch.

John Barentine is an Arizona native and comes to IDA from the "dark side" of science—professional astronomy. He grew up in Phoenix and was involved in amateur astronomy there from grade school. Later, he attended the University of Arizona, beginning research at the National Optical Astronomy Observatories and National Solar Observatory headquarters in Tucson. From 2001 to 2006, he was on the staff of Apache Point Observatory in New Mexico, serving first as an observing specialist on the Astrophysical Research Consortium 3.5-meter telescope and then as an observer for the Sloan Digital Sky Survey. He obtained a Master's degree in physics at Colorado State University and a Master's and Ph.D. in astronomy at the University of Texas at Austin. John has contributed to science in fields ranging from solar physics to galaxy evolution while helping develop hardware for ground-based and aircraft-borne astronomy. Throughout his career, he has been involved in education and outreach efforts to help increase the public understanding of science. In addition to his work for IDA, John is a member of the steering committee of the University of Utah Consortium for Dark Sky Studies and the International Union for Conservation of Nature Dark Skies Advisory Group. He is the author of two books on the history of astronomy, *The Lost Constellations* and *Uncharted Constellations*. The asteroid (14505) Barentine is named in his honor. Follow John on Twitter @JohnBarentine

"Our Place in the Universe"—An Online Astronomy Course Through the University of North Carolina

By Myron E. Wasiuta

Recently, I went online to search "free Internet telescope" just to see what would pop up. As the Director of the Mark Slade Remote Observatory—which most of you know is a free Internet telescope—I wondered whether any other telescopes available for use by the general public were remotely accessible and free. This search produced a number of false leads, including telescopes that were either no longer operational in this way (GLORIA), ones that were still in the concept stage (All-Ireland Robotic Telescope), or others that allowed online watching but could not be directly or indirectly controlled. However, one lead raised my interest—SkyNet.

Clicking the link revealed SkyNet or, more formally, the SkyNet Robotic Telescope Network—a worldwide network of fully automated or robotic telescopes used by professional and amateur astronomers, as well as students over the Internet. Operated by the astronomy department at the University of North Carolina (UNC), it was founded by Dr. Dan Reichart in 2004 with the construction of the first Panchromatic Robotic Optical Monitoring and Polarimetry Telescope (PROMPT). There are now several PROMPT telescopes at the Cerro Tololo Inter-American Observatory (CTIO) in Chile, as well as a couple in Australia. They are about 0.41m (16 inches) in aperture and typically RC design. The purpose of the PROMPTs is to record the light of gamma ray bursts (GRBs) by slewing within a few seconds after detection and to begin simultaneously observing the event at a multitude of spectral wavelengths. Because these telescopes are dedicated to observing GRBs only, about 90% of the telescope time is idle. That's where the concept of SkyNet University comes in. The telescopes are available for use by students and anyone else during the downtime. The SkyNet Network also includes other telescopes, such as the Yerkes 41-inch reflector, a 20m radio telescope, and, more locally, a 0.4m telescope at University of Virginia's Fan Mountain!

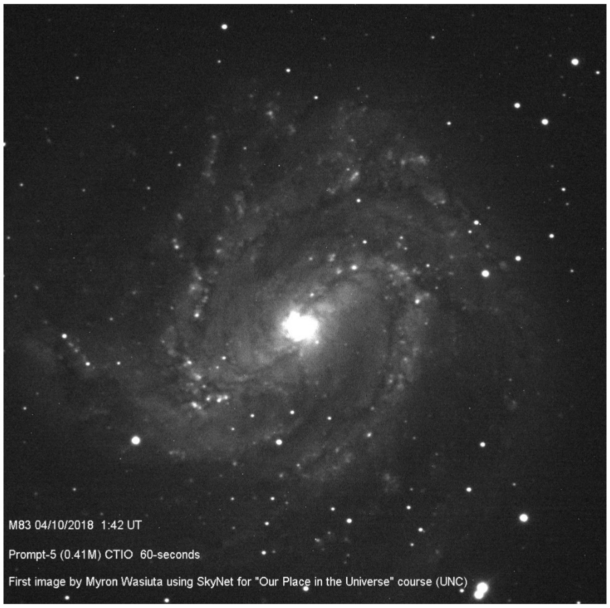
Needless to say, I wanted to try out the telescopes. An easy way to get access was to enroll in the online astronomy course called "Our Place in the Universe." It's a series of online YouTube videos and laboratory assignments taught by Dr. Reichart and his teaching assistants, with 30 minutes of telescope time included to complete the labs. You won't need all this time to complete the course, and the rest of your allotted time can be used for "personal" observing. The course and telescope time are free, but there is a $65 registration fee for the textbook key. I enrolled immediately, and within a day or two got my SkyNet login password and username. The SkyNet login page monitors the telescope, and that's where you select which telescope, filters and exposure times you want for your target observation. The page is pretty intuitive in its use, but when selecting targets, there are certain "rules" that must be considered involving minimum Sun elevation below local horizon and target altitude. However, the graphical display that pops up after you select your target shows when the telescope can image once the parameters of minimum elevation of the target are entered, making it easy to see whether your observation will remain "active" or be able to be "completed" that night.

I found that a really good tool to plan observations at Cerro Tololo is the free desktop planetarium program "Stellarium." Just set it to CTIO, and it will conveniently show you what the sky looks like at that moment as though you were standing on the ground at CTIO!

POP Quiz! What state is CTIO directly south of? (1) California (2) Texas (3) Maine

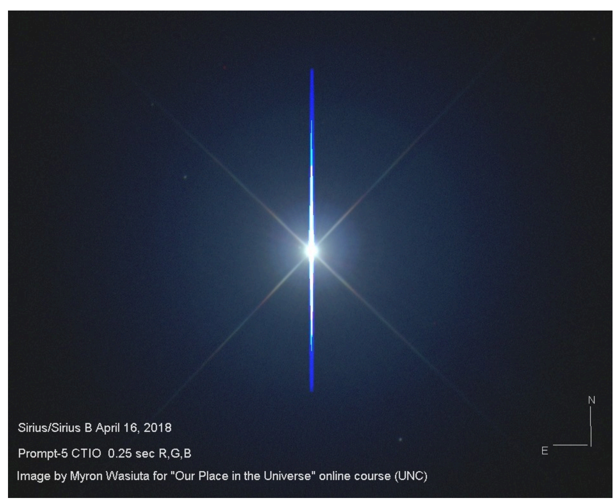
Another interesting fact I didn't realize until I starting thinking in CTIO time is that its longitude is similar to that of Maine! This means that when is getting dark here in Fredericksburg, it's getting dark at CTIO, so there's very little difference in the onset of night and dawn. Of course it's far below the equator, so the splendor of the southern sky is there to be enjoyed!

PROMPT-5 and I Become Acquainted

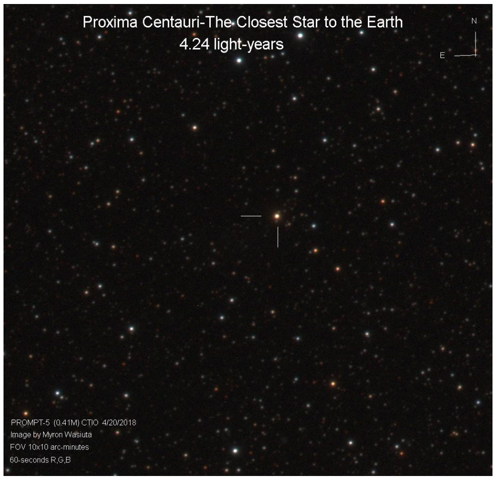


Even before I started the coursework, I wanted to see whether I could figure out the SkyNet platform. So the very night I got my login ID, I entered the password and ID, and to my surprise, a screen opened with a number of telescopes that were available for my use—including a 1.0m telescope! However, I selected the PROMPT-5 telescope after reviewing the imaging specs (0.41m, ccd FOV 10x10 arc-min, image scale 0.69 arc-sec/px). But what should my "first-light" image be? I thought about it for a few minutes, then decided to image an object that could be seen from the MSRO location here so I could re-image it and compare our capabilities to those of the PROMPT-5 telescope under its world-class skies. I also wanted there to be a chance that my image would "discover" something. So I decided on the spiral galaxy M83 in Hydra because there's always a remote chance of finding a supernova. And so I entered in the target, selected the filter (luminance), set the minimum altitude I wanted the galaxy to be imaged (40 degrees), selected the exposure time (60 sec), and pressed "Submit". Immediately, the screen switched and the display showed a summary of my observation with the word "active" next to the PROMPT-5 telescope! Wow—I had just scheduled an observation using a professional telescope at the CTIO in Chile! It was getting late, so I went to bed, but could hardly sleep. The next morning, I logged back into SkyNet and saw the word "Completed" after the PROMPT-5 telescope observation! What a thrill as I opened the image—a beautiful spiral showing thousands of stars with far better resolution than any image I had ever taken of that galaxy. PROMPT-5 and I had become friends!

Sirius and the Pup



Bolstered by my success with M83, I pondered my next target. I strolled out into the backyard that night and looked up. Brilliant Sirius blazed in the south. What, I wondered, must that star look like through PROMPT-5? I thought I would take an exposure to show the brilliance, the intense diffraction spikes that would surely be recorded. But then I remembered! Sirius is a double star—but not just any double. It has one of the most enigmatic objects in the sky nearly perpetually smothered in its fiery glare—a white dwarf. In fact, the *closest* white dwarf to the Earth. I had never seen it nor been able to photograph it despite years of trying. I wondered whether perhaps PROMPT-5 could change that. So, with really no guidelines other than my experience imaging with our fine telescopes at MSRO, I logged onto SkyNet and scheduled my second observation. Unlike my first, I would now try to get a color image by taking a series of exposures using red, green, and blue filters. When I selected the target, the page immediately issued a warning "Intensely bright object in field-maximum exposure will be limited to 0.29 seconds to protect equipment". That's OK, I thought, because I was planning short exposures anyway. I settled on 0.25 sec and scheduled four separate exposures with each of the three filters. After setting my minimum altitude parameters, I saw "active" light up in green and knew my observation would happen! Again, another restless night and again another image in my inbox the next morning. At first, I was disappointed—the image was a densely bloated overexposed image that showed no trace of the white dwarf. I was expecting failure but began processing the green image first. I scaled back on the histogram and applied a gamma scale and there it was! A distinct, tiny dot to the northeast of Sirius—still deep in the glow but definitely there! Measuring the position and separation (10 arc-sec) confirmed that my PROMPT-5 image had recorded the elusive Sirius B! I now had three pups in my life—the white dwarf and two collies we had just gotten a few months ago.



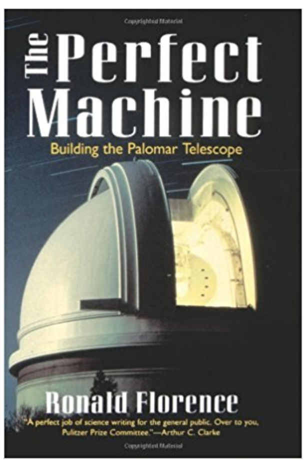
The Closest Star to the Earth

My third image and most recent was again designed to show something close that I had never seen. The star Proxima Centauri has intrigued me since 2016 when it was discovered to have an Earth-sized exoplanet orbiting it. Although very close to the star—this planet orbits in just 11 days—theoretically it should have a solid rocky surface. This could very well be the first exoplanet explored by a robotic space probe because it is the closest exoplanet to the Earth. In addition, Proxima is so close (4.24 light years) that its proper motion and parallax should be apparent in only 6 months or so. Logging into SkyNet again, I scheduled three 60-sec images using the red, green, and blue filters. Once again, the observation was completed the next day. I combined the three monochrome images using Maxim-DL and got a really nice color image of our nearest stellar neighbor.

If anyone has ever wanted to try remote observing using a telescope from a truly world-class location with an intuitive interface—I would definitely recommend SkyNet. And while there are other ways to get time on these telescopes, taking the astronomy course will also help you understand the universe and how it works! However, the joy of remote observing can also be had here at home—the MSRO is available for use. You can visit our Facebook page by searching @remotetelescope.

Book Review: *The Perfect Machine: Building the Palomar Telescope* by Ronald Florence

By Scott Busby



The old road from Pasadena to Palomar ran past the campus of Pomona College in Claremont, through tree-shaded villages, orange groves, clusters of palm trees, and irrigated valleys, before reaching the desert mountain. Eventually, freeways and spreading development would replace the old California of orange groves and palm.

Today, only the climb to the peak from the bottom of the mountain is unchanged from the days when huge tractor-trailers hauled sections of the mounting and the great mirror to the mountain. The road traverses a rainbow spectrum, from the desert oranges and browns of the Native American villages at the base of the mountain, with their ramshackle fences, wandering cattle, and the tired machinery of hard scrabble farming; to the fine greens and tans and splashy wildflowers of the high meadows; and still higher, the dense, dark green of the evergreen forest.

The first glimpse of a telescope dome, from a curve in the road, is a surprise. The dazzling white, glistening in the distance, is like a glimpse of the Domes of Jerusalem by a pilgrim. Even for an astronomer jaded by hundreds of nights on big telescopes, that first sight is electrifying.

There's a long way to go from that first glimpse to the top of Palomar Mountain. The peak is a shallow glen between two long north-south ridges. Outcroppings of granite stand proud in the scrub brush, meadows, and big-cone spruce forest. On a good day the Pacific Ocean is a smear of blue to the southwest, thirty-five miles away.

Palomar is no longer the isolated peak Hussey surveyed in 1903. At dusk darkness comes suddenly to the mountain, but today the overhead canopy of stars is dimmed by the looms of light of Los Angeles to the northwest and San Diego to the southwest. The light pollution would bring chills to George Hale, who thought this remote mountain safe forever.

These passages paraphrase just some of the remarkable words of author Ronald Florence in his book *The Perfect Machine*, published by Harper Perennial 1995, ISBN 0-06-018205-9.

In his book, the author takes you on a fantastic journey of science and engineering through the course of 27 years—1920 through 1947. George Ellery Hale, who had already shepherded three great telescopes (Lick, Yerkes, and Hooker), envisioned a machine that would press the limits of technology, stretching the confidence of a cocky nation perilously close to hubris. But science is compelling and the promise of timeless answers irresistible. And George Hale, as the National Academy Science had learned, was not a man to take no for an answer.

In 1928, America was still the land of optimism and superlatives. Yet amid the optimism and progress, science in America remained a cottage industry. Science worked on hand to mouth budgets. The previous big telescopes at Mount Wilson, the largest scientific projects in the country, had been built piecemeal, dribbling along as Hale raised the necessary funds. The size of the 60-inch reflector was determined by the crucibles at the French glass factories; the disk was the largest blank they could cast in a single pour. George Hale's father, William Hale had provided a money gift that funded the 60-inch, but it would not cover the research or development of larger crucibles. The 100-inch telescope had been a balancing act between the limits of plate glass and riveted-structure technology and the constant struggle for funds from Hooker and the Carnegie Institution. The budget for the 100-inch telescope did not leave room to explore new technology. $6 million was committed for the building of the 200-inch telescope. However, no company or institution had the experience to serve as the equivalent of a general contractor because no one had ever built a machine to the scale and tolerance that the 200-inch required. For the new telescope, there were few working technologies to extend.

Hale was convinced that the new telescope was such a leap in scale that any design based on earlier telescopes and earlier technology wouldn't do the job. It's ironic that the original design of the 200-inch telescope, as crude as it was, began on a napkin and back of a menu drawn by the hand of amateur telescope maker Elliot Porter. Hale and Hale's associates were so impressed with Porter that they offered him a job working on the 200-inch telescope. He was speechless.

The Perfect Machine is a wonderful read and offers nostalgic visions of early modern telescope design and exploration of the Universe by 20th century astronomers. This is a must-read for any amateur astronomer.

Pilgrimage to NEAF

By Linda Billard

In support his employer, Jerry Hubbell made his annual "pilgrimage" to the Northeast Astronomy Forum (NEAF), touted as "the world's largest astronomy and space expo" by its host, the Rockland Astronomy Club. After not going for the last 3 years, Bart and I decided to go this year because the annual meeting of the International Occultation Timing Association (IOTA) was meeting nearby the same weekend. As usual, NEAF was held in the huge field house at Rockland Community College, accommodating dozens of vendor displays, astronomy organization booths, and presentation venues. On Friday, Bart attended the IOTA meeting accompanied in the morning by Jerry.

Courtesy of NASA.

On the weekend, while Jerry spent the vast majority of his time working for [Explore Scientific](#) at the company's booth, Bart and I were able to wander the displays and attend two presentations. The first presentation was by Dennis Conti (Chair of the [Exoplanet Section of AAVSO](#)) on "The TESS Exoplanet Mission and Amateur Astronomer Participation." Conti discussed NASA's launch of the Transiting Exoplanet Survey Satellite (TESS) earlier in the week and explained that amateur assistance would be solicited beginning in June to help scientists identify "false positives" in the TESS data. He outlined, in general, the techniques for finding these false positives. To see a copy of Conti's slides and get more details, visit http://astrodennis.com/

and look at item #21 under “Presentations.” Bart, Jerry, and I are all interested in seeing whether we can do this using the MSRO.

Bart and I also attended a presentation by J. Kelly Beatty and Peter Tyson (both of *Sky and Telescope*) called “Preparing for the Next Total Solar Eclipses.” After a brief discussion of the recent solar eclipse, they described eclipse tours that they had led to various far-flung places such as Kenya and planned tours (sponsored by S&T) to see upcoming total and annular eclipses in such locations as Chile and Argentina. They indicated that there were many companies and organizations that led such tours, including a number of cruise lines, because, quite often, the only way to see a particular eclipse was aboard a ship, particularly those that were visible only in the Southern Hemisphere.

On Friday night, Bart and Jerry used the MSRO remotely from the breakfast room of the Howard Johnson Hotel in Suffern, NY! They successfully documented an ocultation (eclipse) of a star and will be reporting it to IOTA. Proves that you can use the MSRO from anywhere if you have a laptop computer with the right software and an Internet (WiFi) connection! RAC members are encouraged to get trained so you too can use the observatory from anywhere.

Focus On: Rima and Rimae (Volcanic Rilles and Tectonic Trenches)

By Jerry Hubbell

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

Rilles, are very interesting and well documented features on the lunar surface. There are literally thousands of these trenches and more than 330 are documented on [The Moon Wikispaces](#). These features are classified based on their structure and formation. There are straight, sinuous, and concentric type rimae. They are formed via volcanic activity and in tectonic and lava cooling processes. These features are excellent targets to train the eye in observing the lunar surface and in gauging the quality of your high-resolution imaging.

Figure 1. Rimae Sirsalis-LAC74 Grimaldi, Jerry Hubbell, Locust Grove, Virginia, January 7, 2012 0118 UT, 5-inch. APO Refractor (Explore Scientific 127 ED) + Televue 4x Power Mate, Imaging Source DMK21AU04.AS CCD video camera, north/up, east/right. Seeing 7/10, Transparency 5/6. LAC74 April 1962, Aeronautical Chart and Information Center, US Air Force, Lunar & Planetary Institute.

Rimae Sirsalis is a typical linear rille (Figure 1). The LAC 74 chart shows it in the lower center of the frame to the east of craters Sirsalis and Sirsalis A 25 mi (42 km) each. This rille runs for about 182 mi (300 km) and is about 2 mi (3 km) wide according to the Virtual Lunar Atlas. Located at Selenographic coordinates 14°S and 60°W, this feature is best observed 5 days after first quarter, or 4 days after last quarter. Close observation of this rille and its surrounding area reveals the specifics of its formation.

The primary characteristic of its surrounding area is that it is in the lunar highlands, not in an area of lava flow or smooth maria. This indicates that the rimae was more than likely formed via tectonic activity in the crust around that location. If you look at the area several hundred miles to the southeast of Sirsalis, you will find Mare Humorum and Rimae Mersenius, 139 mi (230 km) and 2 mi (3 km) wide, another linear rille system. The formation of these two rille systems, Sirsalis and Mersenius, could have been caused by the impact that created Mare Humorum. Others speculate that Rimae Sirsalis was formed from the tectonic stress when Oceanus Procellarum was formed.

If you look to the southeast on the outskirts of Mare Humorum, you will find concentric rilles Hippalus 145 mi (240 km) long, and 2 mi (3 km) wide, and Campanus. These rilles are the concentric type in that they curve parallel to the shore of Mare Humorum and are tectonic in nature also related to the formation of Mare Humorum.

The third type of rille is the sinuous, which is formed through the volcanic process from lunar volcanoes or through the piercing of the lunar crust and resulting lava flow forming large maria and other smaller lava lakes or lacus. There are myriad examples of this type of rille, Hadley Rille being one of the most famous because of use as a landing site for Apollo 15 (Figure 2).

Name for 18th century inventor, John Hadley, Hadley Rille, 60 mi (100 km) long and 1 mi (1.5 km) wide, is a sinuous rille that runs through a valley by crater Hadley C and Mons Hadley. Located at approximately 3°E and 26°N Selenographic coordinates, the rille winds through the valley and is the result of volcanic lava flow. Adjacent to the southeastern edge of the lava-filled Mare Imbrium impact feature, the steep-walled rille, which is about 1,300 ft (400-m) deep, winds across Palus Putredinis at the foot of the Montes Apenninus (Apennine mountain range).

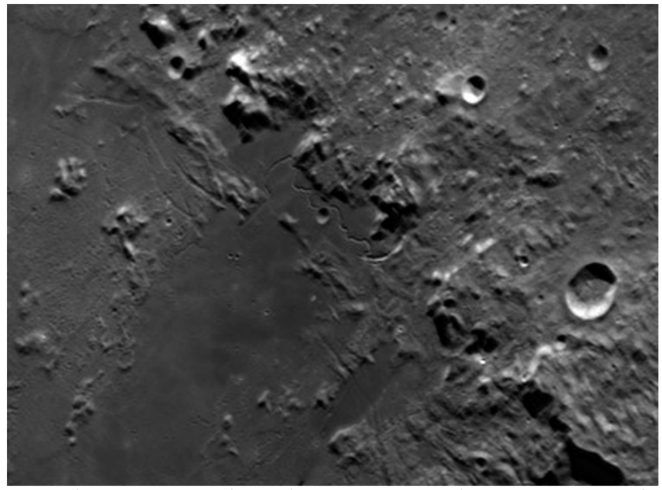


Figure 2. Rima Hadley (crop, 3x enlargement, ed.), Francisco Alsina Cardinalli, Oro Verde, Argentina, September 10, 2256 UT, 0.28-m. SCT (Celestron 11" Edge HD), QHYCCD QHY5-II CCD video camera, north/up, east/right.

Another very well-observed rille system is Rimae Hyginus, 133 mi (220 km) long and 2 mi (3 km) wide (Figure 3), located in the southern part of Mare Vaporum. This rille is very distinct in that it passes directly through and bisects the crater Hyginus 6 mi (10 km), and then to the east, forks into two separate rilles. Immediately to the west of crater Hyginus is a series of very small craters, 2 to 3 mi in diameter that follow the path of the rille. It almost appears that these series of 10–12 craters are sections of the lava tube that originally created the rille and caved in along the path of the rille.

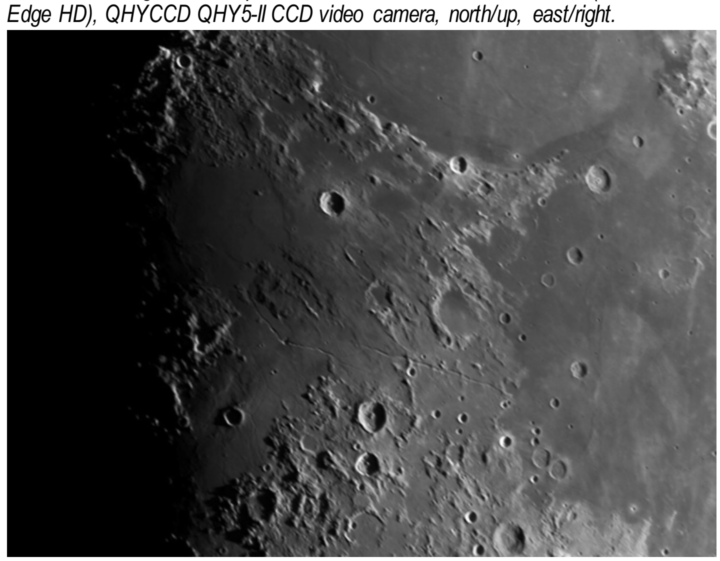


Figure 3. Rima Hyginus, David Teske, Louisville, Mississippi, USA, 26 November 2017 at 0141 UT. Colongitude 356.5 degrees, Seeing 6/10, 4-inch APO refractor + 2.5x Powermate.

These features are some of the most interesting features to observe, not only in terms of their variety of shapes and character, but also in their origins in the formation of the lunar crust. Rilles can almost be considered the fingerprint of the formation of the moon that resulted from the early bombardment of the surface from the thousands of large asteroids and other space debris billions of years ago. The rich variety of volcanic and tectonic trenches provide endless opportunities to spy some of the smallest, yet most distinctive features of the moon. Another example is shown in Figure 4. (This image was featured in the most recent *Journal of the ALPO*, The Strolling Astronomer, Volume 60, Number 2, page 15, Spring 2018).

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Several observations were also received from members of the Lunar Section; here is one such example from Alberto Anunziato from Paraná, Argentina.

Name of feature: Rimae Sulpicius Gallus. **Date and time** (UT) of observation: 01-08-2018 06:20 to 06:55. **Size and type of telescope used**: 105 mm. Maksutov-Cassegrain (Meade EX 105) **Seeing**: 7/10. Magnification: 154X

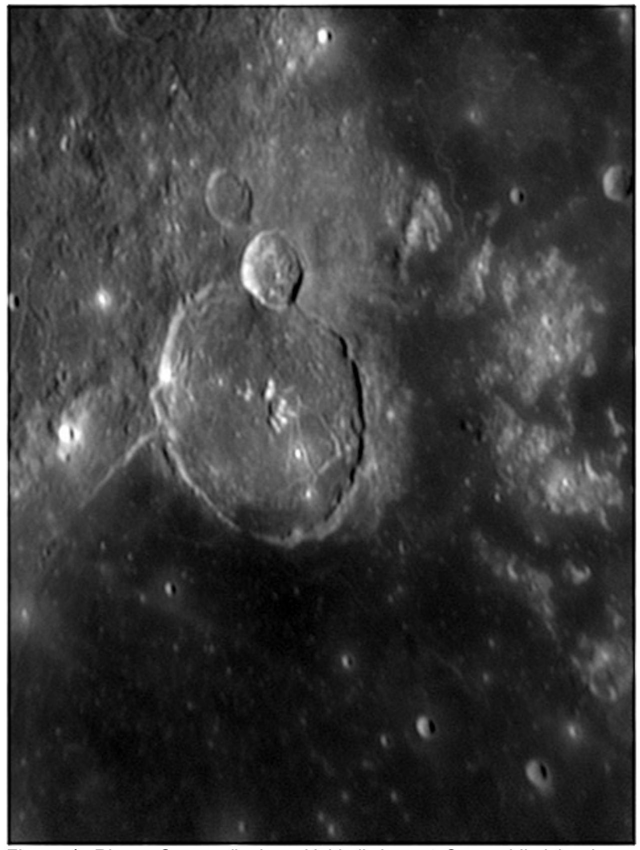

Figure 4. Rimae Gassendi, Jerry Hubbell, Locust Grove, Virginia, January 7, 2012 0128 UT, 5-inch. APO Refractor (Explore Scientific 127 ED) + Telvue 4x Power Mate, Imaging Source DMK21AU04.AS CCD video camera, north/up, east/right. Seeing 7/10, Transparency 5/6

Rimae Sulpicius Gallus is an Imbrium network of three rilles on the southwest shore of Mare Serenitatis. It is located parallel to Montes Haemus and is, in the words of Peter Grego, "One of the Moon's less grand-looking named mountain ranges, a narrow, knobby plateau some 400 km in length that marks the southwestern boundary of Mare Serenitatis. Made up of rounded elevations, its highest summits reach around 2,000 m." Well, Montes Haemus are not very tall but at 163.3º Colongitude, it is their turn to shine, rather, their turn to cast shadows around. The shadows penetrate, rather moderately, in Mare Serenitatis.

In the extreme south, they extend toward Sulpicius Gallus, in front of which a diffusely bright patch is observed, surely one of the high peaks of the mountain range. Then the darker shadows delineate the edges of a gulf-like feature, on one of whose promontories (south) shines Sulpicius Gallus M. The bright spot on the northern promontory shines is a craterlet whose name I do not know but which appears bright in the images of the Lunar Reconnaissance Orbiter (LRO).

To the east, the bright spots are, from south to north, 1) what appears to be Sulpicius Gallus A or a high point of the central Rima—the shadows of Montes Haemus do not allow us to distinguish clearly, 2) what seems to be the highest summit in the area-a bright spot and a diffusely bright area that we also observed in the LRO photographs, 3) and finally what appears to be another craterlet. It is the right moment of the lunation to observe shadows inside the central rille; the west and east rilles barely distinguish themselves as diffuse shadows. The three rimae extend further to the north but the shadows of Montes Haemus hide a considerable part.

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Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes
(Note: There was no meeting in March due to inclement weather.

February 2018—Mark Slade Remote Observatory

Myron Wasiuta gave a presentation and demonstration of the Mark Slade Remote Observatory (MSRO). He began by saying that MSRO was built with help and donations from the club and some members, and he thought of it as an observatory that would allow members more opportunities to observe, helping with the time pressures of the day. The original equipment used to start the observatory was what Myron's friend Mark Slade had assembled for building his own observatory. When Mark passed away a few years ago, his widow Laura decided to donate the equipment so that Myron could build the observatory in Mark's memory and further his interest in sharing pictures and fostering interest in observing the night sky.

About that time, Myron learned that fellow club members Jerry Hubbell and Linda Billard, working with another person, Rich Williams, had just published a book with Springer on remote observing. Together, Myron and Jerry worked out the design of the observatory. With the help of other club members, they built a square building, which was placed around Myron's pier with Mark's dome on top. They worked through getting the telescope and other components connected and working together. Over time, the original telescope had problems. Jerry's employer, Explore Scientific, helped out with telescopes that could be used and tested in the observatory. The telescope was recently upgraded to the Explore Scientific 165-mm APO refractor, along with a 4-inch refractor piggybacked to it with a one-shot color CMOS camera. Myron showed an image of the Horsehead Nebula region made using the piggyback telescope. He said it was a 3-hour sequence that he set up and then let run while he slept.

To make images like Myron's Horsehead Nebula region work, he said you either had to autoguide or measure and correct the errors of the telescope mount's drive (with accurate polar alignment). He said the main MSRO telescope used Telescope Drive Master (TDM) to do the drive error correction and needed the most accurate polar alignment he had ever done.

Myron said the ability to use MSRO mainly involved learning how to log on and how to use two programs: Maxim DL and Cartes du Ciel. He said Cartes du Ciel was a very nice planetarium program that was available as a free download.

A goal for the observatory was to be able to observe on every clear night. Myron said he and Jerry had looked at the MSRO Clear Sky Chart records and compared them with the imaging dates in the last year. They found that of 181 nights that were at least partially clear, MSRO had been used 144 nights for observations. Myron brought up the MSRO page on the club website, which had pictures of the observatory and the telescope inside. He said the picture was of the 152-mm telescope that had been installed earlier. It also had a smaller piggyback telescope that was later incorporated as MSRO3, and was the telescope he had brought in to demonstrate. Myron said the camera for the main telescope had red, green, and blue filters and a grating for spectroscopy. Recently, a V-band filter donated by a friend in Culpeper was added. It was the type of filter preferred by astronomical organizations such as the American Association of Variable Star Observers (AAVSO). The V band was designed to get more consistent wavelength response from various cameras so that their measurements could be better compared.. Myron pointed out a second door showing in the image inside the dome room. He said it was a provision for adding a "warm room" alongside the dome room, but so far, MSRO users had been using the system remotely (as was intended) and so their own houses were their warm rooms.

Myron listed the three telescopes now at the site. In addition to MSRO and MSRO3, a C14 was set up on a pier in the yard with a roll-off structure to protect it from the elements when not in use. It looked a little like an outhouse. He said it was currently planned for use with an interferometer that Bart Billard had designed for making higher-resolution spectra. Myron turned to the demonstration of MSRO3. It was an 80-mm refractor on a mount and stand small enough to be taken to the mountains or moved around the yard to avoid obstructions. It was controllable by wired or WIFI Internet connection and used autoguiding through a smaller piggyback telescope with its own camera. He thought mini robotic observatory packages like it might be available commercially in a year or so. They could enable a network of observatories, along the lines of the GLORIA project that he said was tried some time ago but was limited by the size and expense of the telescopes. Myron suggested telescopes like MSRO3 could do something like it—allow a network of telescopes where an owner could use his own telescope or make it available for others when it was idle.

Myron finished by communicating with MSRO3 via his laptop. He connected using TeamViewer, which showed the MSRO3 computer desktop and allowed him to open Maxim DL and Cartes du Ciel and show how to connect to the telescope. After a few hiccups, he was able to get the telescope to unpark and slew to where the Orion nebula would be if it had been polar aligned. Peter Orlowski asked how polar alignment can use Polaris, which is not exactly at the north celestial pole. Myron explained the mount had a separate telescope on the axis of rotation and that a reticle was provided in the telescope. With the reticle properly adjusted for the sidereal time, pointing the mount so Polaris is in a small offset circle gets the center on the celestial pole. Glenn Holliday joked that you have to adjust your reticle every 400 years (because Earth's axis of rotation "precesses"), and Glenn Faini suggested that was "planned obsolescence."

April 2018—Autoguiding on the Cheap

Tom Watson began his presentation by saying that he could have equally well called his talk something like autoguiding "for amateurs who are not familiar with it." He explained that telescopes that track worked well for visual observing, but asked, "what about taking images?" Tom said German equatorial mounts (GEMs) had an axis to align with Earth's rotation axis (near Polaris in the sky) and some had motors to compensate for the rotation, but even with perfect polar alignment, imperfections in the gearing would cause "periodic errors." With the long exposures needed to image stars and deep-sky objects, the images would be degraded by these periodic errors. Autoguiding was needed to correct these and other errors in the real world.


Orion StarShoot Autoguider. Courtesy: Orion

When Tom won his first telescope from a Celestron image contest (he only had microscope images to submit at the time), he looked for help in getting satisfactory images with it. The cost at the time was prohibitive but has since improved to as little as $350.

Orion Nebula (M42) taken using the StarShooter Autoguider. Courtesy: Tom Watson

Tom said those who were into really fancy telescopes should talk to a more experienced astronomer about more professional solutions than he would cover in the program. He showed a copy of fellow club member Jerry Hubbell's first book, *Scientific Astrophotography*, as an example. Tom showed images of M42 to compare an autoguided image with 38 60-second exposures made with an Orion Short-Tube 80 telescope with an image made with an unguided 103-mm Ritchey-Chretien telescope. He said he used a free program called DeepSkyStacker, and Scott Busby said he also used it and might give a presentation on how to stack images with the program. They discussed image formats they worked with. Tom had to use JPEG or convert to TIFF (but TIFF required a fast computer). Glenn Faini said his JPEGs came out better than raw images. Tom thought he could show Glenn how to get that JPEG quality after working with the original raw images.

Next Tom went over the steps for imaging with an autoguider. Point to Polaris. Check the telescope balance and such adjustments. Connect the guider to the mount using the telephone jack connectors and cable. Connect the guider to the computer with USB. (It sends data to the computer and gets corrections back rather than calculating them and sending directly to the mount. Scott explained that putting the computer in the loop allows it to show you what is going on.) Adjust the guide camera in or out to find the focus (usually not necessary after the first time). Start the software. Tom said he used PhD2 Guiding and found it works great out of the box. He demonstrated the setup, using the simulator to show what the displays were. The image was at the upper left, with a profile of the selected guide star next to it. The software could autoselect the star with a tool provided. For a first-time setup and probably each time when setting up equipment after taking it apart and putting it away overnight or longer, run the smart calibration to allow the program to determine the response to its guiding commands. Tom commented that for a large telescope, it would be necessary to use something bigger than the finder his autoguider was mounted on.

Scott Busby said you could select how "aggressive" the corrections should be, to deal with backlash, for example. Also there was a camera accessory called PoleMaster available for many GEMs. It would "walk you through" polar alignment. Glenn Faini asked about stacking, saying he was not guiding. He thought stacking could achieve the equivalent of longer exposure. Tom described the process somewhat differently, indicating the stacking software tried to select better features from images to combine into the final image. The discussion got into using layers in Photoshop.

Image of the Quarter

Pinwheel Galaxy (March 9, 2018 @Belmont Observatory) by Scott Busby

The **Pinwheel Galaxy** (**Messier 101**, **M101** or **NGC 5457**) is a face-on spiral galaxy 21 million light-years away from Earth in Ursa Major. First discovered by Pierre Méchain in 1781, it was one of the final entries added to the Messier Catalogue by Charles Messier.

About this image, Scott says: "After working through some processing techniques with 1.5 hours of data, I've got a presentable image. I could always use more data, and over the next month, I'll add more to M101. Nevertheless, here it is in all its glory. This is what one can achieve with the ZWO ASI1600MM-C camera on a 12-inch scope."