http://www.raclub.org/

# The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 2, Vol. 5 August 2016–October 2016

## Message from Tucson

By Ron Henke

It turns out that there are two types of star parties held by the Tucson Amateur Astronomy Association (TAAA)—star parties for the public, usually in conjunction with a sponsoring organization, and star parties for club members only at the two club locations. I have participated in both.

Last weekend, I participated in an event for a Boy Scout troop. It turned out that the Scout Master was an amateur astronomer himself. The event looked a lot like any event in Virginia, except for two things—there was a lot of dirt and three scopes were scheduled for the event but five showed up. Eighty participants attended. I got to talk a lot about my new favorite objects, clusters. Although the TAAA puts a 2-hour time limit on its public events, the time limit is not closely adhered to. That's fine by me. Spending time with the public is what makes these events fun. On this occasion, we started at 6 p.m. and finished about 9 p.m. Unfortunately, the Moon was full, which, of course, played havoc with some of the objects we wanted to see. I don't know why, but the Moon seems to be brighter here than in Virginia.

As I mentioned above, TAAA has two dark sites. The dark site I haven't been to yet is the Chiricahua Astronomy Complex (CAC). It's actually known as the VERY dark site. The CAC is said to have some of the darkest skies in southern Arizona. It's a 2-hour drive, 110 miles away and truly in the middle of nowhere. Hopefully, I will make it out there soon. Winter's coming, and the site is at 4,800 feet, so it gets cold. The site already has a number of resources, including 10 concrete pads with power for viewing, 4 RV hookups, a 14-inch Celestron SCT, a shower room, and couple of other creature comforts. Already funded and almost completely planned is a bunkhouse with showers, a kitchen with eating area, a meeting area, and a roll on–roll off observatory large enough for four scopes. Once this is all complete, the investment in the CAC will be about $1 million. For more on the CAC, click here.

Now to the place I *have* been. The closer site (27 miles/45 minutes away) is at the Tucson International Modelplex Park Association (TIMPA, an air field for model airplanes). This turns out to be a great relationship. TIMPA uses the park during the day, and the TAAA uses it at night. There are six concrete pads with power and a 14-inch Meade SCT. As with the C14 at the CAC, you can take a class to be certified to use the 14-inch Meade at TIMPA. (*cont'd page 4)*

**TIMPA Dark Site. In the background is the housing for the 14 inch Meade SCT.**

## How to Join RAClub

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

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

**RAClub annual membership is $20 per family. Student membership is $7.50.** Click here for a printable PDF application form.

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

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

The StarGazer
August 2016–October 2016
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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Jerry Hubbell, Astrophotography
Myron Wasiuta Mark Slade Remote Observatory (MSRO)

### Calendar of Upcoming Events

| | |
|---|---|
| Star Party, Caledon State Park | November 5 |
| Night in Washington's Day, Ferry Farm* | November 12 |
| Star Party, Caledon State Park | December 10 |
| Star Party, Caledon State Park | January TBD |

### Recent Outreach Events Completed

| | |
|---|---|
| Star Party, Pratt Park, Stafford County | September 10 |
| Mary Washington ElderStudy Group | October 6 |
| Meet the Moon, Porter Library | October 8 |
| Star Party, Caledon State Park | October 22 |

*See special event box on page 3.

## President's Corner

**Welcome to New RAClub Members (August–October)**

- Bret Mullinix

This month's newsletter has a great variety of articles and highlights all the great things the club members have been doing this year. Our previous club president describes his experiences in astronomy from Arizona, and our vice president highlights his journeys from this summer. The newsletter also has wonderful articles about music, the Moon, and a book review of *Einstein's Telescope* by Evalyn Gates. We have had a busy year and expect the upcoming year to be the same. Please check out our upcoming events at raclub.org. Of particular interest is the special event at Ferry Farm described in the box below.

See you under the stars, Scott Lansdale

## Special Event : Night in Washington's Day, November 12

Location: George Washington's Ferry Farm
Saturday, November 12: 6:00 p.m.–9:00 p.m.
Families and visitors of all ages can learn about the history in the night sky through the constellation stories known to George Washington and other early Americans. Witness a theater scene depicting Revolutionary War soldiers by their campfire. Discover how early Americans used lanterns, candles, and other ingenious lighting technology to banish the dark. Enjoy stargazing led by the Rappahannock Astronomy Club (weather permitting). Children can make a paper-bag 'tin punch' luminary or their own constellation. Everyone can enjoy a campfire and roasted marshmallows.

## Astronomy Math by Scott Busby

When you read in an astronomy book that there are three hundred billion stars in our Milky Way galaxy, how would you make sense of that number? Certainly, if you need to do calculations with numbers in this format, you must be able to translate from words to decimal notation or scientific notation. The table below translates some of the words describing large numbers used in astronomy.

| Words | Decimal Notation | Scientific Notation |
|---|---|---|
| Thousand | 1,000 | $10^3$ |
| Million | 1,000,000 | $10^6$ |
| Billion | 1,000,000,000 | $10^9$ |
| Trillion | 1,000,000,000,000 | $10^{12}$ |
| Quadrillion | 1,000,000,000,000,000 | $10^{15}$ |

*Example: Write three hundred billion in scientific notation and decimal notation.*

Three hundred billion can be thought of as three hundred *times* one billion, or $300 \times 10^9$. (In normalized scientific notation, this is $3 \times 10^{11}$.) Written out in decimal notation, this is 300,000,000,000. A trick for going the other direction—from decimal notation to words—is to start at the left of the number and read to the right in groups of three zeros at a time. In this case, first you see "300" ("three hundred"), followed by ",000" (making it "three hundred thousand"), followed by another ",000" (making it "three hundred million"), then one final ",000" (making it "three hundred billion"). Take the following quiz to check your understanding. (Answers are on page 16.)

| Words | Decimal Notation | Scientific Notation |
|---|---|---|
| Three million | (a) | (b) |
| (c) | 12,000,000,000,000 | (d) |
| (e) | (f) | $1 \times 10^5$ (or just $10^5$) |
| Half a billion | (g) | (h) |
| (i) | 95 | (j) |

***(continued from page 1)…***

This is the darkest site I have been to as an amateur astronomer. This is not to say that that it is completely dark, but the arms of the Milky Way are clearly visible. Because the site is a good distance from any mountains, trees, or houses, there is an almost 360-degree unobstructed view of the sky. I will say that Jupiter acquires quite a shimmer low on the horizon.

The two times I have been at TIMPA, there have been about 20 people and 15 telescopes there—all types of scopes, from a 4-inch Newtonian on a Dobsonian mount to a 12-inch Celestron that took two people to put on the mount. Each time I have been to TIMPA, I have set up next to a gentleman named Jim O'Connor. Much to my surprise, I found out that he used to live in Aquia Harbor. Not only that, he was a member of the Triangulum Astronomy Club, the precursor to the current RAC. They used to meet at Myron's house. Jim is retired, so he has a lot of time. He did 50 events last year. The club itself scheduled 110 events but only 90 were held owing to weather constraints. Jim uses a 10-inch Meade SCT. He does not do visual astronomy, however. He has a live video camera that is very sensitive and pulls in more detail than one would be able to see visually, especially color. Jim is the astronomy historian and folklore expert for the club and is very proficient in talking about the night sky.

The highlight of the summer for Jane and me was having dinner with Jerry and his family. It was great to see them all again. That's all for now. Clear Skies.

## Astronomical Journeys: What I Did on My Summer Vacation!

By Jerry Hubbell

Over the years, I have been fortunate to be able to turn my astronomical hobby into my professional avocation and enjoying some of the benefits of being employed by a vendor who travels all over the world showing our equipment. In 4 months, I made four trips to various places on the West Coast that boast dark skies. I had the opportunity to meet some of my co-workers in person for the first time and to talk to hundreds of customers over the course of 13 days of showing our equipment. I also took some long overdue time off with my family to visit Arizona for 10 days. On that trip, we traveled almost 2,000 miles, visiting several locations, including the Grand Canyon, Tombstone, Phoenix, Tucson, Sedona, Flagstaff, Monument Valley, and Sonoita. Near the end of our trip, we met up with former RAC president and friend Ron Henke and his wife Jane in Tucson and had dinner at the resort area where

they now live. (See previous article for a picture.) We had a great meal and discussed both astronomy and geology, discovering that our wives Jane and Michelle have a mutual interest in rocks and gems that rivaled our love of astronomy.

Scott Roberts, President and founder of Explore Scientific, LLC, and Greg Bragg, Director of Specialty Sales, were my companions at the star parties. Scott and Greg have been traveling around the United States since February hauling a vintage 1968 Airstream trailer outfitted to be our mobile command post at the various sites. By the end of the year, Greg and Scott will have driven more than 20,000 miles and to at least 12 star parties. I was invited, as Director of Electrical Engineering for Explore Scientific, to demonstrate, discuss, and explain the design and operation of the product of 3 years of work—the PMC-Eight mount control system. The rest of this article details some of the highlights of these trips.

### Riverside Telescope Makers Conference (RTMC), Big Bear City, CA

RTMC is one of the oldest events held in the United States dedicated to telescope building. It is held every year over the 3-day Memorial Day weekend. The conference was moved to Big Bear City in 1975 so that stargazing could be included as part of the event. Big Bear City is a beautiful location near Bear Mountain at 6,800 ft. elevation. I flew in to Ontario Airport near San Bernardino and was picked up at the airport by my colleague Dan Dickerson. He and I have been working on the recently released ExploreStars® application for the mount controller I have been working on for the past 3 years. We drove to the RTMC location, which took only a couple of hours. It's at the YMCA campground called Camp Oakes. The skies were awesome, and the people were as nice as they could be. Temperatures while we were there were in the 70s during the day and dropped into the 40s in the evening. The Milky Way was a sight to behold. That was the first time I had been to such a dark a site. We showed our equipment and explained its operation. That evening, we spent time testing the Losmandy G-11 mount with the PMC-Eight controller and the ExploreStars® application on the tablet. We struggled a bit to get the mount to behave, and over the 3 nights we were there, showed our system off while also identifying some issues with the all-sky 1, 2, and 3-star alignment code. Fortunately, I was able to correct those issues before the next star party in Bieber, CA.

In addition, I assisted a customer who had had some failures with his Telescope Drive Master (TDM) electronics. Because I am the main service engineer for the TDM, I arranged to have some spare parts brought to the star party since the customer planned to be there. Turns out he had come all the way from Mexico City, Mexico, to enjoy the skies! I repaired his TDM within a few minutes and demonstrated that it was working while he watched the whole process. It was a great 3 days of activities and skygazing that I won't forget anytime soon!

### Golden State Star Party, Bieber, CA

This time I flew into Reno, NV, on June 29. After departing Dulles Airport at 6 a.m. (a *very* early start), I arrived in Reno about noon and picked up my rental. I drove 4 hours to northeastern California to the very small town of Bieber (population 312) located in cattle ranch country. The rolling hills and long vistas were a sight to behold. Mount Shasta was prominent on the horizon 80 miles to the west. After meeting Scott and Greg at the small roadside "Bieber Motel" (reminded me of the "Bates Motel"!), we had dinner at the excellent Old Mill Grill across the street. Owner Toy Canto is a great hostess, and she


**Golden State Star Party Entrance with Mount Shasta in the Background (Jerry Hubbell)**

prepares the best food around. We then got ready for an evening of demonstrating our equipment at the star party site located on a ranch 8 miles away at an altitude of 4,200 ft.

The weather cooperated fully over the 4 nights we were there, although the temperature dropped down into the 50s by midnight. The sky was very dark and transparent, and the Milky Way was glorious. I remember stepping out of the trailer after doing some work on the mount system right after twilight and looking up to see some clouds on the horizon. I questioned Greg about that, and he said "That's the Milky Way!" I was astounded. The skies were very dark and transparent at Big Bear, but we were surrounded by hills so the Milky Way did not impact me like that there. We stayed up very late on the last night we were there, and I left on Sunday, July 3 about noon to drive back to Reno to fly home.

### Table Mountain Star Party, Oroville, WA

**Scott Roberts and Greg Bragg at the Grand Coulee Dam (Jerry Hubbell)**

After another very early start on August 2, I left Washington, DC, for Spokane. I met Scott and Greg near the airport in Spokane, and we drove 4 hours northwest toward the Canadian border to our hotel in Oroville. On the way, we stopped at the Grand Coulee Dam and took some photos. It is a beautiful setting with mountains and canyons.

When we arrived in Oroville, it had started to rain. Our plan had been to go to the star party site at Eden Valley Guest Ranch that evening, but we didn't want to attempt that in the rain. The next day, we were up early and set up the trailer and all the equipment. Greg has been going to this event for several years, so he was right at home. As soon as we set up our equipment, stargazers of all types started asking questions, and everyone seemed to be glad we were there. I had a great time talking to everyone about our new mount controller and about my books. As always, I enjoy talking to people who have used my books and our equipment and hearing what a difference they make in people's enjoyment of the hobby.

After spending 5 days at the ranch, Scott, Greg, and I left August 6 at about noon for Spokane. I had a few hours before my flight, which was scheduled for about 8 p.m. However, unbeknownst to me, the trip home would take more than 30 hours because that was the day that United Airlines' computer system crashed. I spent the night in Seattle in the airport terminal. Not fun! I arrived home about midnight Monday evening.

## Meteor Crater, Meteor, AZ

One of my primary reasons for wanting to take a vacation in Arizona was to visit one of the great geological formations in the United States—Meteor Crater—formally known as Barringer Crater. It was originally named to honor Daniel Barringer, who first suggested that the crater was the result of a meteoritic impact instead of the prevailing belief that it was volcanic.

Ever since I was a kid, I had wanted to visit the crater just to get closer to an actual formation that looked like the Moon. My special interest in the Moon began in the Apollo days of the late 60s, and this was one more way I could enjoy my flights of fancy about traveling to the Moon.

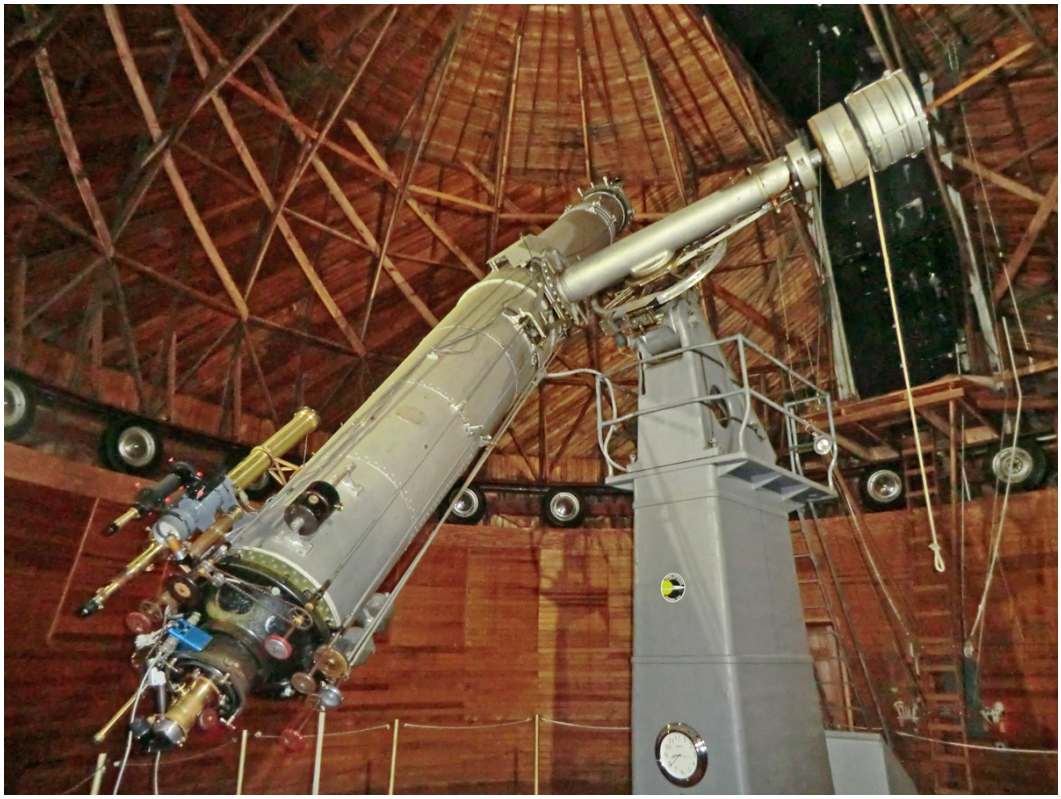
**The Hubbells at Meteor Crater.**

The drive up to the crater was very cool, and the visitor center is well worth the time to go through all the exhibits and presentations. I think I would like to visit again. I won't scratch if off my bucket list just yet!

## Lowell Observatory, Flagstaff, AZ

**Lowell Observatory 24-Inch Clark Refractor Dome (Jerry Hubbell)**

Lowell Observatory was founded in 1894 by world-renowned amateur astronomer Percival Lowell. A fanatic about Mars, Lowell built this observatory in Flagstaff to pursue his passion for the red planet. Located at 7,200 ft. on "Mars Hill," it houses several famous telescopes. My family and I spent an afternoon touring the observatory and got a close-up look at the recently refurbished 24-inch Clark refractor. The observatory staff has written a beautifully illustrated book entitled *The Far End of the Journey: Lowell Observatory's 24-inch Clark Telescope* (Lowell Observatory Publishing, 2016), describing the history of the Clark refractor up to and including the latest refurbishment. This telescope is particularly famous for the discovery of Pluto. Lowell became interested in talk of a ninth planet, and so in 1906, he began his quest for the elusive world he named "Planet X." He searched the skies unsuccessfully until his death in 1916. The hunt stalled until 1929 when the observatory director assigned 23-year-old Clyde Tombaugh to resume the search. He found it February 18, 1930. After taking a few weeks to confirm, the observatory formally announced the discovery on Percival Lowell's birthday, March 18, 1930.



**24-Inch Clark Refractor at Lowell Observatory (Courtesy Lowell Observatory)**

After our tour of the 24-inch Clark refractor, we visited the gift shop full of neat items for purchase. Overall, a very nice visit, although the weather was cloudy and rainy. For that reason, I did not have the opportunity to look through the instrument. Maybe next time! This was the fourth Clark refractor I have had the pleasure of seeing in person. The others were the 26-inch Leander McCormick Refractor at UVA; 26-inch telescope at US Naval Observatory, Washington, DC; and the 20-inch telescope at Chamberlain Observatory, Denver, CO. These instruments are wonderful to see, and continue to be used for astronomy outreach in their respective communities.

### Winer Observatory, Sonoita, AZ

Located some 40+ miles southeast of Tucson, Sonoita, with a population of 818, is a beautiful location for the Winer Observatory at 4,900 ft. I visited this observatory because it has become significant to me in different ways starting in the mid-1980s. The founder and director of Winer Observatory Mark Trueblood is a pioneer in the field of remotely operated telescopes and the author of *Microcomputer Control of Telescopes* (Willmann-Bell, 1985). This book was a pivotal work for me because it sparked my interest in telescope control systems. It was also my good fortune to have worked previously with Dr. Russell Gene, the co-author of Mark's book. He later provided the foreword for the book *Remote Observatories for Amateur Astronomers* (Springer, 2015), authored by myself, Linda Billard, and Rich Williams. Mark has had a distinguished career as an engineer and scientist, working on several NASA projects, including the Hubble Space Telescope control room systems, Gemini Telescope, and the NOAO's 4-m telescopes on Kitt Peak and in Chile. Most recently, he has served as a member of the OSIRIS-REX team.


Mark Trueblood and me exchanging books

Mark founded and built the Winer Observatory in 1983, and has been the director ever since. Over the past 30 years, the observatory has hosted some of the most significant remotely operated telescope systems in the world. I contacted Mark in July, introduced myself over the phone, and explained my interest in visiting his observatory since we were headed there in August. He graciously invited me to visit and confirmed that he would be there on the appointed date.

Driving south from Tucson to Sonoita was a pleasant trip of a little over an hour. Mark took me through the observatory, including the workshop, computer and communications room, control room, and the roll-off roof observatory, which is 25 x 50 ft. Our visit was during the summer monsoon season in Arizona, which means everything was as green as it was going to get, but the observatory was closed because of the afternoon storms that roll through the area.

The Winer Observatory hosts several systems sponsored by universities around the world and also a couple that are sponsored by individuals doing cutting-edge work. Entities such as the University of Iowa, Ohio State University, a university in Poland, and NASA/Goddard Space Flight Center use the Winer Observatory to host their systems. I have personally used the University of Iowa Rigel telescope hosted there through the Sierra Stars Observatory Network. We talked about a couple of interesting systems, including the NASA telescope, and his all-sky camera system. I had brought my copy of *Microcomputer Control of Telescopes* with me on this trip for Mark to sign, and he was happy to do that. I offered a copy of my book *Scientific Astrophotography* that I had with me to show him, and he was very keen on receiving it. I signed it for him and we took a photo to record the occasion. I had a great time meeting and getting to know him and look forward to talking with him in the future.

This past summer was a once-in-a-lifetime adventure, but I hope to visit other places like these in the future. My new career in astronomy is truly a challenge and a gift for which I will forever be grateful. If you ever have the opportunity to visit these and other astronomy locations—carpe diem—don't let it pass by.

## Music of the Stars

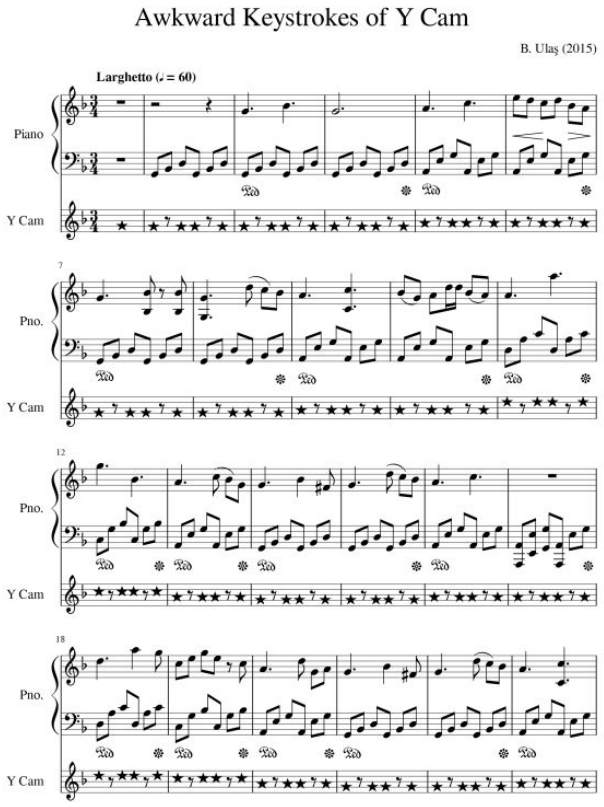
By Linda Billard

*Asteroseismology,* sometimes called stellar seismology, is a relatively new sub-discipline of astronomy. Its practitioners attempt to better understand the internal structure of pulsating stars by studying their vibrations. Just as seismic waves moving through Earth provide information about its interior, sound waves passing through a star tell us about its inner workings.

In 2008, the BBC reported that scientists had recorded the sound of three stars similar to our Sun using France's Corot space telescope. In this early work, Corot detected the oscillations as subtle variations in the light emitted by the star as the surface wobbled. This light signal could then be converted to sounds. In an article in *Science*, the researchers said that the sounds had enabled them to collect information about processes deep within stars for the first time. They determined that the regularly repeating pattern indicated that the entire star was pulsating. In addition, they noted that individual stars had different patterns. They concluded that stars had different sounds depending on their age, size, and chemical composition.

Since then, asteroseismology has blossomed to include studies focused on red giants, our Sun, and other Sun-like stars. However, perhaps the most novel project to date was reported in the July 2015.

Mankind has long associated celestial bodies with music. A researcher named Burak Ulaş reported on a whimsical project in which he and his team generated musical chords from the oscillation frequencies of the primary component of the oscillating eclipsing Algol system Y Cam. Ulaş reported that Y Cam A had enough oscillation data for use in creating chords. It is a binary system, which accounts for its twinkling, but instead of a steady on-off blinking, it oscillates at four different frequencies. Ulaş mapped the lowest tone to the pitch "A" on the musical scale using the free online music synthesizer Audacity, and then used that as a base to map three of the star's oscillating frequencies to pitches commonly used in a chord progression popular in much of modern music—G, C, D. Playing the "tune" in the manner in which it was "broadcast" by Y Cam A resulted in an unusual melody. To expand the composition, Ulaş incorporated piano music he had previously created based on Y Cam A's whole tones that corresponded to the diminished whole tone scale often used in jazz music. The result is an other-worldly mix of pulsating sounds and a rather austere piano melody.




**Sheet music for the composition. Credit: arXiv:1507.07307 [physics.pop-ph]**

This composition is based on a single star—Ulaş envisions using a multitude of other stars to drive music played on a variety of instruments. Together he thought they could provide the basis for an entire cosmic orchestral piece for use in video games, as the soundtrack for space based movies, or simply as something interested people could listen to while pondering the vast night sky. Read more here.

## Focus On: Montes Apennines and Palus Putredinis

By Jerry Hubbell

*(Note from the author: A version of this article was published in the September 2016* ALPO The Lunar Observer *as the Focus On bi-monthly article. Part of my role as the Assistant Coordinator (Lunar Topographical Studies) is to write articles periodically on research done by ALPO contributors. To see full-size versions of the photos, go to http://moon.scopesandscapes.com/tlo.pdf )*

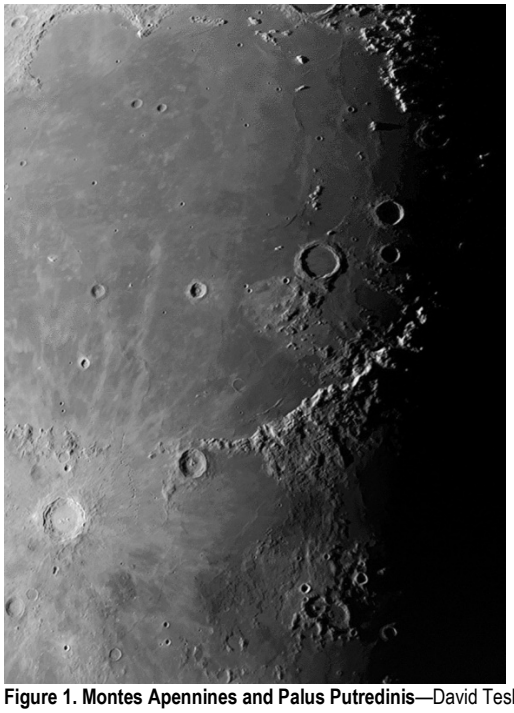


**Figure 1. Montes Apennines and Palus Putredinis**—David Teske—Starkville, MS, 14 November 2014 1137UT, Seeing 6/10, North/Up, East/Right, 3.5" Maksutov-Cassegrain, Skyris 445 video camera.

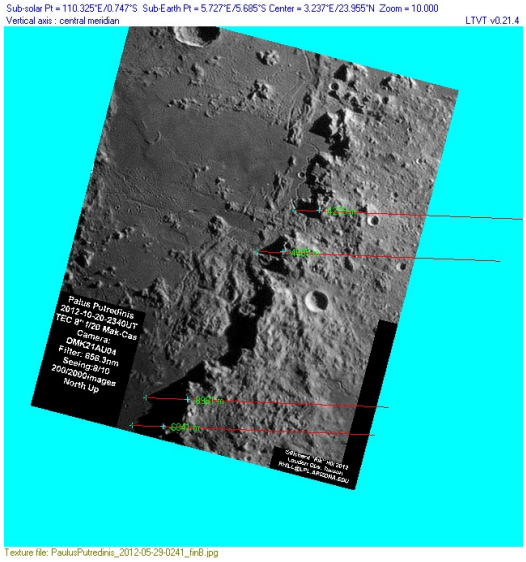



**Figure 2. Montes Apennines—Palus Putredinis LTVT Measurements**. This image by Rik Hill—Tucson, AZ, shows several peaks, 2 of which are measured to be almost 9 km and 7 km in height in the lower portion of the image. 20 October 2012 2340UT, Seeing 8/10, North/Up, East/Right, 8" Maksutov-Cassegrain, DMK21AU04 video camera with IR filter. Processed by Jerry Hubbell in LTVT.

This article continues our look at some smaller features of the Moon referred to as Palus or "plain." Also called "marshes," they are actually small stretches of lava plains. These often-overlooked areas are adjacent to other more prominent features. The area of the lunar surface known as the Montes Apennines and Palus Putredinis "Marsh of Decay" contain features that are of significance, including Mons Hadley and the Hadley Rille visited by the Apollo 15 mission. The Montes Apennines (see Figure 1) are one of the most popular mountain ranges observed on the Moon and also one of the easiest to study. There are several named peaks in this range, including Mons Wolf, Mons Ampère, Mons Huygens, Mons Bradley, and Mons Hadley. Mons Hadley is often considered the highest mountain on the Moon.

Images of the peaks around Montes Apennines provide the opportunity to practice using the program LTVT, the Lunar Terminator Visualization Tool. This program provides the tools to measure the heights of mountain peaks and crater rims on the lunar surface (see Figure 2).

I encourage observers to try using LTVT on your images, or other images available on the ALPO website. Comparing your measurements to other sources, such as the Apollo era LAC charts available online, would be a very interesting project. I will be writing more about this in future articles and encourage and appreciate suggestions.

The adjacent lava-flooded plain known as Palus Putredinis (Fig. 3) is a level lava-flooded plain with the crater Autolycus to the north and the Montes Archimedes to the west. The selenographic coordinates of the Palus are 26.5° N, 0.4° E, and it is 100 miles in diameter. Rimae Archimedes lies in the southernmost area of Palus Putredinis. Rimae Hadley lies to the east of the Palus. The small submerged crater Spurr lies just northwest of the center of Palus Putredinis and is the site of crashed spacecraft Luna 2.

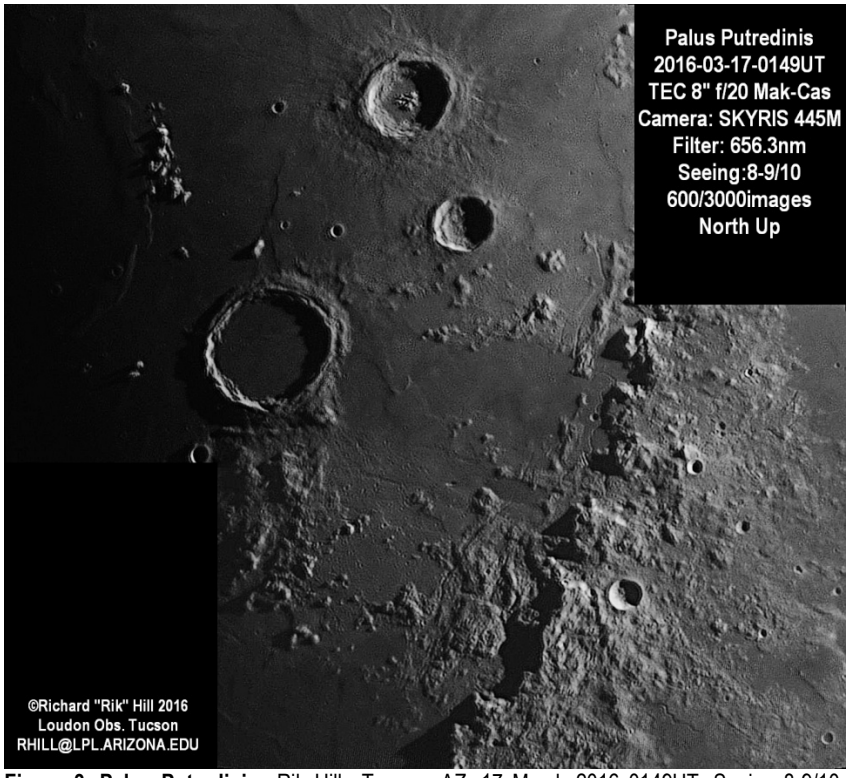



**Figure 3. Palus Putredinis—**Rik Hill—Tucson, AZ, 17 March 2016 0149UT, Seeing 8-9/10, North/Up, East/Right, 8" Maksutov-Cassegrain, Skyris 445 video camera with IR filter.

As mentioned previously, the Apollo 15 mission destination was Hadley Rille. This mission explored the region around the rille and Mons Hadley. The astronauts David Scott, James Irwin, and Alfred Worden explored the Hadley Delta and Hadley Rille area of the Palus Putredinis region over a 3-day period using the first lunar rover on the Moon.

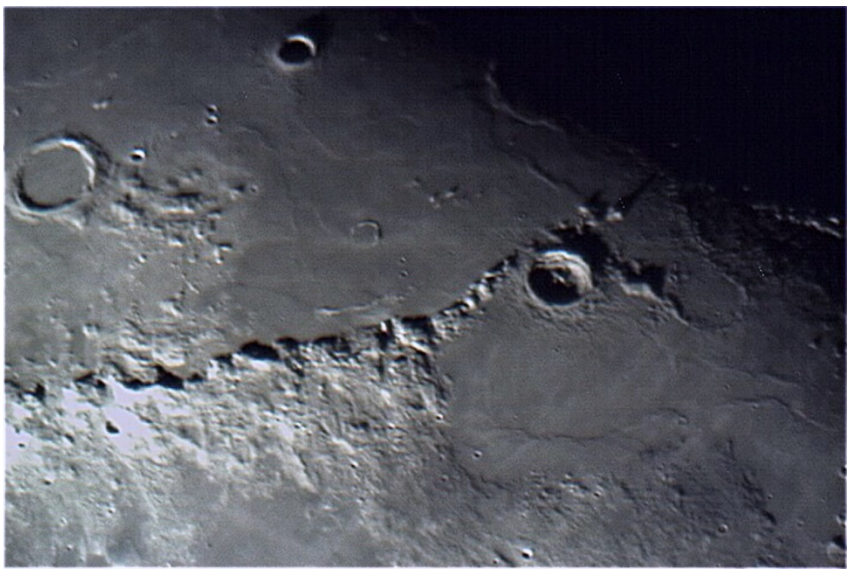


**Figure 4. Palus Putredinis—**Jay Albert—Lake Worth, FL, 14 June 2016 0246UT, Seeing 7/10, North/Right, East/Down, 11" SCT, video camera.

**Additional Reading:**

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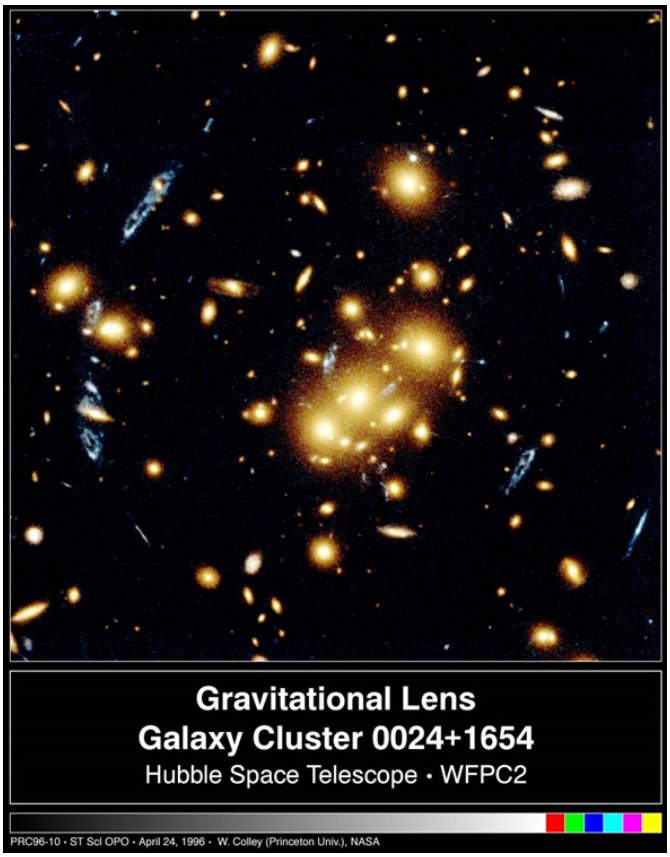
## Book Review: *Einstein's Telescope* by Evalyn Gates

By Bart Billard

In her preface to *Einstein's Telescope*, Evalyn Gates offers to acquaint the reader with the "incredible ideas and images that are shaping and reshaping our understanding of the cosmos. It is offered in the same spirit that musicians proffer there music to the world—to be absorbed in many different ways at many different levels." For me she has done well at achieving that goal.



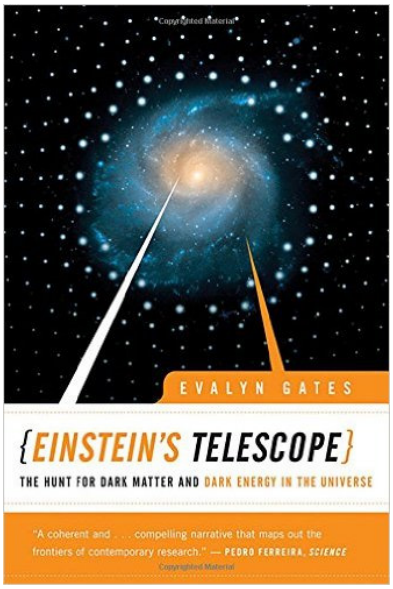

**Sample illustration from *Einstein's Telescope*. The yellow-orange galaxies of Cluster 0024+1654 along with the associated dark matter form distorted images of a distant galaxy at about 4, 8, 9, and 10 o'clock (and also near the center of the image). Source: a Hubble image available at the *Einstein's Telescope* website.**

Dr. Gates recommends starting with the color illustrations at the center of the book, which can be enjoyed on their own and then revisited at the end and while reading. One is the Hubble image to the left. The yellow-orange galaxies belong to the cluster indicated. The odd-looking blue objects are multiple images of a single galaxy billions of light years beyond the cluster.

The title of the book refers to gravitational lensing, which Einstein predicted from his theory of general relativity in a 1936 paper, providing an explanation of the distant galaxy in the image. Sir Arthur Eddington's 1919 solar eclipse expedition had confirmed the theory's prediction of the bending of light because of distortions of spacetime near massive objects. (The special and general theories of relativity show that space and time are not distinct but are entwined as "spacetime".) Einstein's 1936 paper showed that the bending of light caused by gravity of a nearer star could produce double images of a more distance star, and in the right circumstances, even a ring around the lensing star. Now computer modeling of mass distributions (including dark matter) in galaxy clusters can produce trial-and-error reproductions of the images of

background galaxies in observations like the Hubble image shown, with the result that a map of the mass distribution of the cluster can be reproduced to reveal the location of the dark matter.

The book explores the question, "What is the universe made of?" At a point when some were beginning to suggest physics was nearly complete (1970), Vera Rubin and Kent Ford, followed by other astronomers, uncovered new evidence in galaxies of the existence of large amounts of "dark matter," meaning some substance with mass that neither emits nor absorbs light to allow us to see it. More recently, evidence of the acceleration of the expansion of the universe has led to the idea of another unseen component, "dark energy." Gates explains the development of the current understanding of the makeup and evolution of the universe to the present point where we know much about the makeup of 5 percent of the universe, but little about the next 23 percent (dark matter), and almost nothing about 72 percent (dark energy). The question has become: "What are dark matter and dark energy?"




As explained in the book, gravitational lensing is a powerful tool for astrophysicists. If dark matter in halos of galaxies includes "massive compact halo objects" (dubbed MACHOS), they should produce "microlensing events" like stars do. (In microlensing events, a foreground star, usually in the disk of the Milky Way, passes in front of a distant star in the central bulge, causing the brightness of the background star to grow and then fade in a characteristic manner because of the magnification by the gravitational lens.) Surveys had logged about 500 microlensing events a year, with only 1 definitely consistent with microlensing by a black hole and 2 others possibly consistent by the time the book was written. Other examples involve the trial-and-error computer modeling of lensing by galaxy clusters. They allow researchers to "see" the distribution of the dark matter in the lensing cluster. In the case of the Bullet cluster (actually two clusters that have recently collided), the derived distribution of dark matter shows it is still associated with the two groups of galaxies. Meanwhile, hot gas detected by X-ray telescopes has been left behind by friction, appearing in the space between the groups of galaxies that have recently passed each other by.

I found Dr. Gates' writing clear and interesting. The story is much more detailed and comprehensive than I can convey in a short review. She starts with descriptions of developments in physics and cosmology needed for background and ends with a discussion of gravitational waves, including possibilities of detecting them directly with interferometers like LIGO (which was not sensitive enough at the time but succeeded a year ago) or indirectly in their effects on the pattern of the cosmic microwave background radiation. If you want to know more about the book, I mostly agreed with the Amazon review by J Moran, although it was not quite clear to me how he arrived at 4 stars instead of 5.

## Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

### August 2016

[Note: The club picnic is held in August in lieu of a regular meeting so there is no presentation..]

### September 2016—MSRO Projects

Myron Wasiuta and Jerry Hubbell made presentations on the Mark Slade Remote Observatory (MSRO). Myron presented "A Discussion of Possible Observing Projects Using the Mark Slade Remote Observatory." He said the MSRO was a free Internet telescope, but not the first. He had found a free Internet telescope that began operating

in 2007, the Seeing in the Dark Internet Telescope, operated by Cornell University and PBS with a National Science Foundation grant. There would be no charge for using MSRO; however, RAC members would have priority.

The MSRO was named in honor of Mark Slade, Myron's friend and fellow club member from the early days of the club. The Meade LX200 telescope and dome, along with the Dome Works system for operating the dome were donations from the estate of Mark Slade, and additional donations from the club and several individuals made it possible to complete the observatory.

Myron listed several suggestions for projects possible with the observatory: general astrophotography, wide-field nova patrol, narrow-field nova patrol, supernova patrol, variable star observation, and asteroid orbit and light curve measurement. The wide-field nova patrol project would employ the ASI 120-mm camera that currently serves as the telescope finder. It could take 10-second exposures reaching 8th magnitude. He said he expected a nova could be found about every 5–10 years. Narrow-field nova patrol with the main telescope would best search places with concentrations of many stars, for example, globular clusters. Myron said that estimates indicated a nova frequency of one every 2 years in the Milky Way globular clusters, which would imply about one every 4 years for those that MSRO could search. He said spiral galaxies, especially merging, starburst galaxies would be favorable for supernova searches. Even a supernova distant enough to reach only 16th magnitude would be detectable.

Myron suggested variable star observation was interesting, and there weren't enough telescopes for all the variables that could be observed. Some examples he gave included cataclysmic variables, reverse novae (stars like R Coronae Borealis that suddenly dim instead of flaring up), recurrent novae (like T Coronae Borealis or RS Ophiuchi), pre-main sequence or protostars (such as R Monoceritis and FU Orionis), and helium flash stars (highly unpredictable stars at the end of their lives that are forming planetary nebulae).

Asteroid orbits can change, so observations are useful. Myron said the MSRO computer had a database of 730,000 asteroid orbits to aid in finding them to measure their positions by taking and analyzing images (astrometry). In addition, photometry on asteroids could measure light curves from which their rotation could be measured, and occultation timing could help resolve their size and shape in addition to providing position measurements.

Myron ended by showing spectroscopic measurements made with MSRO. One was the quasar 3C 273, whose spectrum showed its red shift. He also illustrated how to distinguish a small planetary nebula from a star using the emission line spectrum.

Jerry gave a short presentation on how spectroscopy can be done on MSRO. He showed the RSpec website operated by Tom Fields, who provided the SA-200 grating for MSRO. This grating would diffract some of the light from stars into a line of colors to the side of the star's image on the CCD. Jerry had the grating turned in the filter holder to orient the line along the declination axis. Analysis software from the RSpec website read the spectrum from the CCD image.

Jerry also showed a setup he designed based on a fiber-fed spectrometer. This spectrometer had a connector to hold the tip of a fiber-optic cable carrying starlight from the focus of the telescope so that the light from the fiber passed through an entrance slit. The spectrometer had a collimating mirror, grating, and focusing mirror all aligned as needed to project the spectrum of the light from the fiber onto a linear CCD chip that measured the spectrum.

Processing electronics in the spectrometer then sent the data to a computer for analysis. Jerry designed and built a fiber-optic head to connect the other end of the fiber to a telescope. The fiber-optic head also split infrared light not needed for the spectrum and directed it to a guide camera. The guide camera allowed focusing and aligning the star's image so that its visible light entered the tip of the fiber at the opposite end of the cable from the spectrometer.

### October 2016—How Astronomy Invented Pretty Much Everything

Glenn Holliday began by saying that his presentation was updated from one he used about a year ago for the Kenmore outreach. His first slide, "People=Astronomy," showed artifacts 25,000 to 37,000 years old with possible astronomical interpretations. One had tally marks that could be used in tracking the lunar month, and another had shapes suggestive of phases of the Moon. He said anthropologists such as Brian Hayden have pointed out fireplaces, rings of stone, and other structures up to 100,000 years old that seem consistent with modern primitive societies that all have sophisticated astronomy with constellations and star names. Jerry Hubbell commented that our brains are built for pattern matching. Glenn also said modern primitive cultures tend to have secret societies with special knowledge, typically including astronomy. They are the beginnings of differentiation into elites, according to Hayden and other anthropologists.

Glenn also showed "Art=Astronomy" and "Stories=Astronomy." For example, a 13,000-year-old (Middle Stone Age) cave drawing in France shows a bull with a pattern of dots above it suggestive of the Pleiades. Also, cultures in both Europe and America, which had had no contact for at least 20,000 years, have similar stories of hunters chasing a bear across the sky and of seven people who end up in the sky as stars. He also illustrated "Writing=Astronomy" with a Babylonian tablet that concerns the sky, and "Math=Astronomy" with, among other examples, a 2,300-year-old Babylonian tablet that was translated and studied recently to reveal use of Kepler's Second Law of Planetary Motion to predict Jupiter's position with geometry, by approximating a curve with a polygon divided repeatedly (the beginnings of calculus). Navigation dates back 4,000 years, geometry 3,000 years, and trigonometry 2,500 years (including spherical trigonometry).

**Every gentleman of the Enlightenment was an amateur scientist. This is 1 of 15 telescopes owned by George Washington. Credit: Mount Vernon**

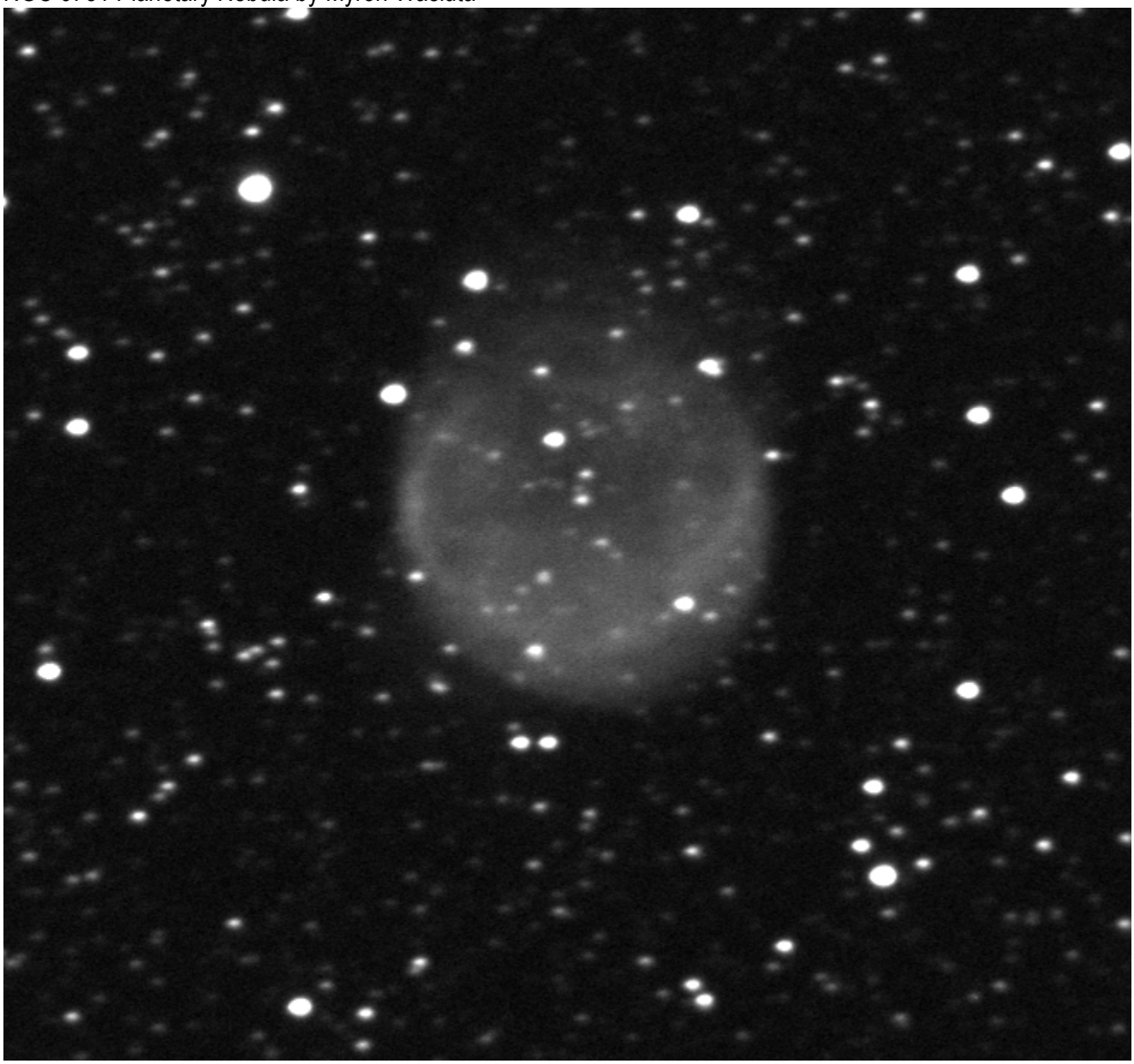
Technology served as the marker for the transition to more recent history of astronomy. Glenn showed an Iron Age (2,700 years old) lens, the oldest known, and Galileo's second telescope, from 1609. He noted Galileo's enthusiastic publication of his observations with the telescope, which provided evidence in support of the Copernican system, amounted to our first modern science writing. Two supernovas 35 years apart,—Tycho's star in 1572 and Kepler's star in 1607—also stimulated development of the new astronomy by contradicting the Greek idea that the stars are unchanging. Glenn learned that the first student protest at Harvard was a response to its astronomy course teaching the Earth-centered system instead of the Copernican system of the planets. He said three bright comets in 1664, 1680, and 1682 fueled the public imagination, the publication of almanacs, and astrology in America. He traced our modern citizen science (amateurs can sometimes do science when professionals can't) to the Enlightenment, when gentlemen were amateur scientists. George Washington had 15 telescopes. The pace has continued to accelerate since. Uranus and Neptune, the first planets since ancient times, were discovered by Herschel and Galle, and Neptune's existence was predicted theoretically before the discovery. Spectroscopy in the 19th century and rocketry in the 20th provided more tools for astronomy. Glenn showed an example of astronomy on other planets: Curiosity took a picture

of Earth and the Moon in the Martian sky. He closed with a picture of the James Webb Space Telescope, slated to be the next telescope to go into space and asked whether the one after that could be on the Moon.

[**Answers to the Math Astronomy Quiz on page 3**: (a) 3,000,000. (b) $3 \times 10^6$. (c) twelve trillion. (d) $12 \times 10^{12}$. (e) one hundred thousand. (f) 100,000. (g) 500,000,000. (h) $5(100 \times 10^6)$ or $(5 \times 10^7)$. (i) ninety-five. (j) $10^2 - 5$, or $(.95 \times 10^2)$ or $(.095 \times 10^3)$].

## Image of the Quarter

NGC 6781 Planetary Nebula by Myron Wasiuta



Myron says: "I used MSRO tonight [August 6, 2016] to make some variable star observations and then had some time to play around! Took two deep CCD images of a planetary [nebula] in Aquila [shown here] and then the dwarf galaxy NGC 6822 (Barnard's Galaxy). The nebula image is a stack of ten 2-minute sub images, cropped in slightly. Camera used is the ATIK 314e and the MSRO 12-inch LX-200 at f6.4."