http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club | No. 3 Vol. 7 November 2018–January 2019

Letter From a New MSRO User

By Shannon Morgan as told to Linda Billard

Last year, I was pleased to be accepted into the NASA Solar System Ambassadors Program (SSA). As some of you may know, RAC members David Abbou and Lauren Lennon are also in this program. The SSA program works with motivated volunteers across the nation to share the latest science and discoveries of NASA's missions through a variety of events that inspire their communities. Shortly after I was accepted, I happened to see a post on the SSA program's Facebook page from Lauren regarding the planned training program for the Mark Slade Remote Observatory (MSRO). I was intrigued and got in touch with Lauren right away.

M 95

Explore Scientific 165mm ED APO refractor at f/5.1 with 0.7 FRFF
QHY 174m-GPS 21 x 180s
Mark Slade Remote Observatory, Virginia by Shannon Morgan

I've been fascinated with astronomy since I was very young. My mother nurtured this interest by ensuring I had the opportunity to learn about and watch all NASA's launches. I pursued this interest into adulthood, majoring in astronomy at Appalachian State University (ASU). The university has a very active astronomy program, with multiple observatories housing 14-, 16-, 18-, and 32-inch telescopes. During my time at ASU, I did research on eclipsing binaries and programmed and built an observatory control system. Since college, I have been working in IT but have maintained my own "budget" astrophotography setup. However, the MSRO opportunity was fortuitously timed because back problems have recently limited my ability to haul equipment. MSRO has been the perfect solution for me to continue doing astronomy right from my home office.

Explore Scientific 102 APO Refractor f/7
QHY 163c OSC TEC camera
Explore Scientific / Losmandy G11
Explore Scientific TDM Telescope drive corrector
Comet 46P Wirtanen
37 x 60s
2018-12-08 04:24 UTC
Mark Slade Remote Observatory, VA
Shannon Morgan and Myron Wasiuta

My current MSRO project involves finding and photographing exoplanets transiting stars. I have been helping Jerry Hubbell in this effort. I feel my biggest contribution so far has been to write a program that sifts through NASA's list of confirmed exoplanets to help determine which transiting exoplanets can actually be seen by the MSRO at its particular location. The program has two processes: (1) selects exoplanets of magnitude 11 or brighter with suitable declination for the MSRO site and that are known to transit a star; (2) fine tunes the results for the MSRO location to ensure that the exoplanet can be seen after dark and that the whole transit will be visible in the available open sky at the MSRO location. I re-run the program for the NASA list every few weeks because that list continues to grow as a result of new discoveries. (Continued on page 4)

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. We also have several members who live outside Virginia and have joined to have the opportunity to use of the Mark Slade Remote Observatory (MSRO)—one of the benefits of joining the club."

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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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	February 2
Science Night, Conway Elem. School	February 21
Star Party, Caledon State Park	March 2
Star Party, Caledon State Park	April 6
Math & Science Night, Park Ridge Elem.	April 10

Recent Outreach Events Completed

Star Party, Stratford Hall	November 10
Star Party, Embrey Mill (Stafford)	November 17
Star Party, Caledon State Park	January 6
Star Party, Mt. View HS Science Club	January 11
MSRO Session, Orange County HS	January 17
MSRO Session, Orange County HS	January 25

President's Corner

I wish you all a very Happy New Year and offer my humble thanks for entrusting me with the office of president of your club. I will endeavor to fill the shoes of those who worthily preceded me.

One of my goals as president is increasing club membership so that we can do more. I'm sure you have at least one friend who is interested in astronomy and isn't a member. I challenge everyone to bring at least one new member into our club in 2019.

Another of my goals is to make great looking Rappahannock Astronomy Club embroidered gear available to club members. In the next few months, we hope to offer RAC embroidered patches and a wide variety of clothing to club members at a reasonable price. I will keep you posted.

Wishing you transparent skies and excellent seeing.

Glenn D. Faini

Did You Know?

In the mid-1800s, British opticians and scientists had long been experimenting with optical glass; theirs was as irregular as the American product. For these reasons, Alvan Clark made his first lenses from objectives of old instruments. Fortunately, his need for better glass coincided with the midcentury political upheavals that caused George Bontemps, who was privy to the technical secret of making fine optical glass, to emigrate from Paris and to join the Chance Bros. glassmaking company in Birmingham, England. Soon thereafter, Chance Bros. began supplying the Clarks with optical disks. Around 1875, the Clarks turned to the house of Feil-Mantois in Paris for their glass. All the large objectives figured by the Clarks were made possible only by the successful castings of these two Factories.

Source: *Alvan Clark and Sons, Artists in Optics,* Debra Jean Warner, Smithsonian Institution Press, 1968

Astronomy Math: Magnification by Scott Busby

This year, we are going to go back to some astronomy math basics to refresh everyone's memory as well as to provide some easy computations for new amateur astronomers.

Do you know what magnification you're using to view an object through your telescope? At a star party when a visitor asks, "What's the power or magnification of this telescope?" you ought to be ready to provide a quick answer. To quickly calculate the magnifying power of any telescope and eyepiece combination, simply divide the **focal length (FL)** of the telescope's objective lens or mirror by the FL of the eyepiece. Remember to always use the same unit of measure to avoid confusion. Eyepieces are usually sold by FL in millimeters while telescopes are often sold by FL in centimeters or inches. Don't forget to convert before calculating!

$$\text{Magnification} = \frac{\textit{Focal Length of Objective}}{\textit{Focal length of Eyepiece}} \quad \text{OR} \quad \text{M} = \frac{\textit{Objective FL}}{\textit{Eyepiece FL}}$$

For example, using a refracting telescope with a FL of 900 mm and an eyepiece with an FL of 20 mm, what is your magnification?

$$\text{M} = \frac{900\text{mm}}{20\text{mm}} = 45\text{x}$$

What if you're using a Schmidt-Cassegrain Telescope (SCT) with a FL of 3000 mm and the same eyepiece?

$$\text{M} = \frac{3000\text{mm}}{20\text{mm}} = 150\text{x}$$

Keep a "cheat sheet" listing the results for each of your eyepieces when used with your telescope. That way, if you forget and don't want to do math in your head, you're ready with the right answer. Here's an example of a cheat sheet:

Telescope/EP	5 mm	9 mm	12 mm	20 mm
150 mm (6") f7.33 Refractor—1,100 mm FL	220x	122x	91x	50x
78mm (3") f8 Refractor—630 mm FL	126x	70x	52x	31x
60mm (2.4") f5.9 Refractor—355 mm FL	71x	39x	29x	18x
250mm (10") f12 SCT—3,000 mm FL	600x	333x	250x	150x

Letter From a New MSRO User (continued from page 1)

When Linda asked me whether I had ideas for other projects, I said that because January wasn't very good for observing already-identified exoplanets—many of those on NASA's list are in Cygnus, which isn't visible at this time—I was considering another idea. I've been thinking about how to use my program in some other way until Cygnus reappears…Enter NASA's candidate exoplanet list! I'm thinking about running the program on that list with some modifications since the data are less robust and then observing selected exoplanets to see if I can see a transit.

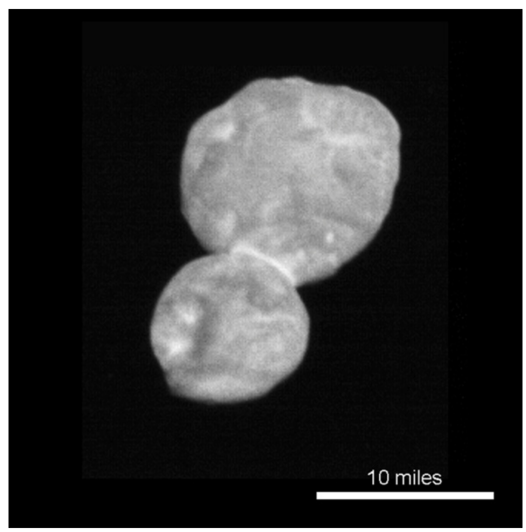
In closing, I would again like to thank RAClub and the MSRO Commission for the opportunity to use such a great system. During my first telescope training session with Jerry, as I was watching the observatory computer on my screen, it was immediately clear what a tremendous labor of love the MSRO has been for a lot of people. Having built a telescope control system in the early 1990s, I am keenly aware of the work that goes into one. I've used a few different remote telescopes in the past year, both commercial and free, but the MSRO outperforms them all in every way possible—not just a little bit, but by orders of magnitude. What I enjoy the most is getting the full experience of using the telescope; I feel like I'm sitting right there even though I'm more than 200 miles away. No other remote observatory I've used offers complete control of the system. While it is, of course, a pleasure to use this quality of equipment, it's the countless hours of fine tuning of the mechanical performance, software, and attention to maintenance that impress me the most. I can only imagine Mark Slade would be thrilled to have this wonderful facility named in his honor. Thanks to Lauren, Jerry, and Myron, I am very fortunate to be a member of the RAC with access to this unique astronomical treasure, and I'm looking forward to a road trip to meet everyone in the club this summer or fall!

Shannon Morgan
Durham, NC

New Horizons: Pluto, Ultima Thule, and Beyond

By Linda Billard

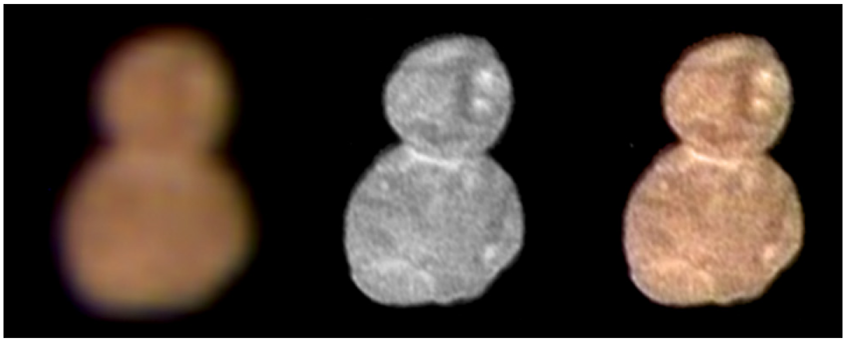
NASA's New Horizons spacecraft had already exceeded expectations, collecting piles of data on minor planet Pluto. However, shortly after midnight on January 1, it executed a stunning flyby of Kuiper Belt Object (KBO) Ultima Thule to get the first photos and data of a contact binary object. It came within about 2,200 miles of the KBO, zooming past the object at more than 32,000 mph. PBS television's Nova science series filmed the activity in the control room before and after the flyby was confirmed, and subsequent photos showed spectacularly clear images of this relatively tiny object (about the size of Washington, DC). You can stream the Nova program here.



Ultima Thule. This image was taken at 5:01 UT on January 1, 2019, just 30 minutes before closest approach from a range of 18,000 miles, with an original scale of 459 feet per pixel. It was taken by the Long-Range Reconnaissance Imager (LORRI. Credit: NASA/JHUAPL/SwRI

The Johns Hopkins Applied Physics Laboratory designed, built, and operates the New Horizons spacecraft, and manages the mission for NASA's Science Mission Directorate. The Southwest Research Institute, based in San Antonio, TX, leads the science team, payload operations, and encounter science planning. New Horizons is part of the New Frontiers Program managed by NASA's Marshall Space Flight Center in Huntsville, AL.

According to Alice Bowman, New Horizons Mission Operations Manager, although Ultima Thule is much smaller than Pluto, the spacecraft collected about the same amount of data (7 gigabytes). However, because Ultima Thule is more than a billion miles farther away, it takes considerably longer for the data to reach Earth. All of it is relayed via the weak signal of a 15-watt radio!



The first color image of Ultima Thule. Taken at a distance of 85,000 miles at 4:08 UT on January 1, 2019, it highlights the reddish surface. At left is an enhanced color image taken by the Multispectral Visible Imaging Camera (MVIC), produced by combining the near infrared, red, and blue channels. The center image, taken by the LORRI, has a higher spatial resolution than MVIC by a factor of about five. At right, the color is overlaid onto the LORRI image to show the color uniformity of the Ultima and Thule lobes. Note the reduced red coloring at the neck of the object. Credit: NASA/JHUAPL/SwRI

According to a January 3 NASA announcement, data from the spacecraft are yielding scientific discoveries daily. Among the findings made by the mission science team so far are the following:

- Initial data analysis found no evidence of rings or satellites orbiting Ultima Thule that have diameters larger than 1 mile.
- Data analysis has also not yet found any evidence of an atmosphere.
- The color of Ultima Thule matches the color of similar worlds in the Kuiper Belt, as determined by telescopic measurements.
- The two lobes of Ultima Thule—the first Kuiper Belt contact binary ever visited—are nearly identical in color. This matches what is known about binary systems that haven't come into contact with each other, but rather orbit around a shared point of gravity.

“The first exploration of a small Kuiper Belt object and the most distant exploration of any world in history is now history, but almost all of the data analysis lies in the future,” said principal investigator Alan Stern of the Southwest Research Institute in Boulder.

Data transmission from New Horizons paused for about a week while the spacecraft passed behind the Sun as seen from here on Earth. Data transmission resumed January 10, starting a 20-month download of the spacecraft's remaining scientific data. "Those of us on the science team can't wait to begin to start digging into that treasure trove," said Stern.

But New Horizons isn’t done with its adventures. It will continue to study the Kuiper Belt until at least April 2021 when its current mission funding ends. The team is already looking toward a hyperextended mission. They expect to have plenty of fuel left after Ultima Thule to try to find another KBO. The Kuiper Belt stretches from about 30 to about 55 astronomical units (AU), and Ultima Thule is in the middle of it. According to Stern, New Horizons will be in the Kuiper Belt until 2027 or 2028. "It would be silly not to look for another target," he said.

However, the hunt for the new target might prove more difficult than originally anticipated. While New Horizons was on its way to Pluto, researchers spent *years* combing the sky with the Hubble Space Telescope before finding three potential targets and selecting Ultima Thule because it was the closest. The next target will orbit even farther out, making it potentially even fainter and more difficult to see from Earth.

The best telescope for discovering the next target might be New Horizons’ own camera. Project Scientist Hal Weaver said that it might be possible to modify the flight software so that the Long Range Reconnaissance Imager (LORRI), the spacecraft's camera, could be used to find KBOs along New Horizons' path. LORRI could take hundreds or even thousands of photographs of the stars around the spacecraft. Rather than send those images back to Earth, it might be possible to program the onboard computer to search for the best targets and only send home those images. Weaver said that such plans are still on the drawing board.

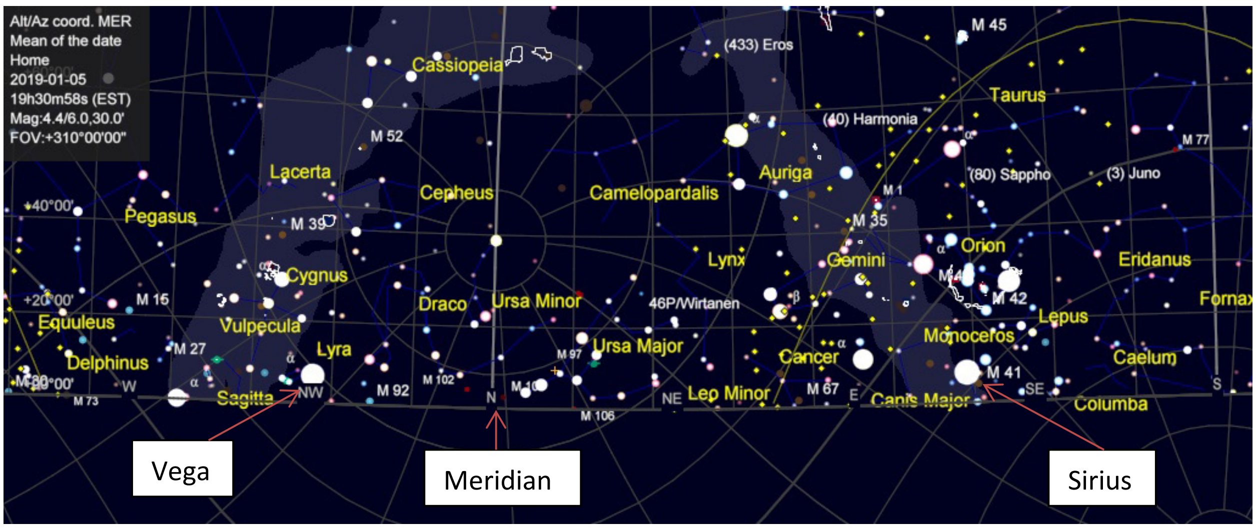
First 2019 Star Party

By Glenn Holliday

The first star party of the year at Caledon State Park is sort of like breaking the ice on a new pond in January. Except it was not cold enough for ice and not wet enough for a pond—which was all good for our desire to see the sky. On a cool January 5, we had five telescopes on the field, seven RAC club members (including a family group—hooray for bringing the whole family to observe!), and six guests (including another family group). The sky was clear, although the seeing was not great, and a steady view came and went during the evening.

The big, showy planets were behind the horizon, but we had good views of Mars. As soon as Orion got above the trees, the Orion Nebula was the attraction. I searched for comet 49P, but without success in the eastern horizon glow.

I noticed I could see Sirius rising through the trees in the southeast at the same time that I could see Vega setting through the trees in the northwest. (Carte du Ciel chart below shows position at 7:30 pm on January 5.) Sirius is best known as the brightest star in the sky, and only slightly less well known as the namesake of the Sirius Cybernetics Corporation (the grossly inept technology company in *Hitchhiker's Guide to the Galaxy*). Its location in the sky is Right Ascension (RA) 6:45:09, Declination (DEC) -16° 42' 58", while Vega is located at RA 18:36:56, DEC +38° 47' 01". The two are close enough to halfway across the sky from each other that you can also see the symmetry of their relative location repeat, inverted, when Vega rises and Sirius sets early in the morning.



Unfortunately, it's not so easy to see this synchronized rising-and-setting at a reasonable evening hour in the warm months. That horizontal balancing act happens before sunset. If you know where to aim, you may be able to see them with telescopic aid. But this pretty coincidence is another argument for observing in the winter time.

See you in February for Groundhog Day.

Special RAC Outreach Events in the Past Quarter

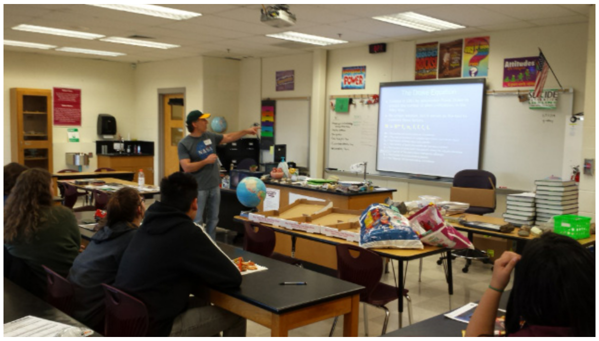
By David Abbou and Linda Billard

Vega, Taken 11/17/18 by Tom Watson at the Embrey Mill event

In addition to our regular star parties at Caledon (see list here), the club also holds star parties at other venues on occasion.

On November 17, RAC members David Abbou, Scott Lansdale, Ryan Raposa, and Tom Watson and Mark Burns, held a star party in the Stafford County community of Embrey Mill. This event had been postponed several times this past summer because of bad weather. Although it was a chilly evening, they had about 50 residents stop by to view the Moon, Mars, and Saturn through their telescopes.

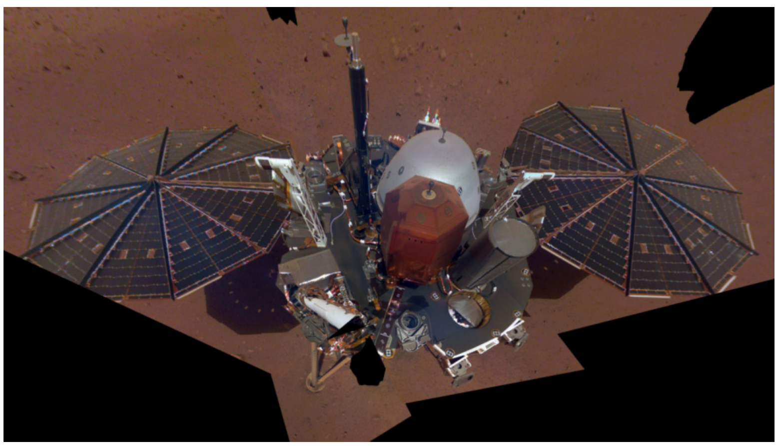
On January 11, David also provided an astronomy and space program presentation to the Mountain View High School Science Club. About 11 students and the science teacher attended the presentation which took more than an hour. As always, David mentioned RAC at the beginning of the presentation during his personal overview. NASA provided numerous outreach materials, which are shown in one of the photos. David also brought one of his meteorites, which all the students got to examine. Overall, it was a great event and well received.



David Abbou at Mountain View High School

NASA’s InSight Deploys Its Seismograph on Mars

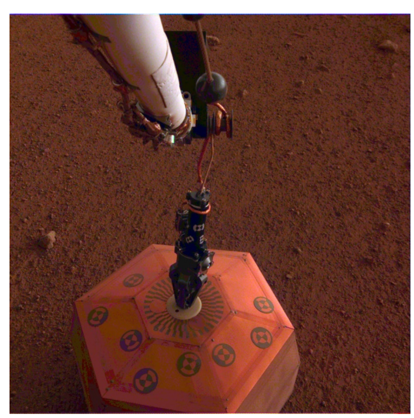
By Linda Billard



NASA's InSight’s First Selfie on Mars. It displays the lander's solar panels and deck. On top of the deck are its science instruments, weather sensor booms, and UHF antenna. Image Credit: Nasa/JPL-Caltech.

A couple of weeks after arriving on Mars in late November, NASA's Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) lander deployed its first instrument, completing a major mission milestone. This was the first time any spacecraft has robotically placed a seismometer on the surface of another planet. The seismometer, called Seismic Explorations for Interior Structure (SEIS), is the copper-colored object in the image below, which was taken at about Martian dusk.

Before deploying SEIS and the heat probe (also known as the Heat Flow and Physical Properties Probe, or HP^3), InSight team members had to verify that the robotic arm was working properly. They also had to analyze images of the Martian terrain around the lander to select the best places to deploy the instruments. SEIS was placed directly in front of the lander, about as far as the arm can reach—5.367 feet away.



Deployment of InSight’s SEIS. Credit: NASA/JPL-Caltech.

"Seismometer deployment is as important as landing InSight on Mars," said InSight Principal Investigator Bruce Banerdt, based at JPL. "The seismometer is the highest-priority instrument on InSight: We need it to complete about three-quarters of our science objectives."

SEIS will measure seismic waves caused by marsquakes, meteorite strikes, and other phenomena. Each marsquake acts as a kind of flashbulb that illuminates the structure of the planet's interior. Watching how these waves travel through the planet’s interior will help scientists study how Mars’ crust, mantle, and core are layered. It will also reveal more about how all rocky bodies are formed, including Earth and its Moon.

While the team has been working to deploy InSight’s two dedicated science instruments, the Rotation and Interior Structure Experiment (RISE), which does not have its own separate instrument, has already begun using InSight's radio connection with Earth to collect preliminary data on the planet's core. It likely will take a year before scientists have enough data from this experiment to provide some results.

In the coming days, the InSight team will work to level the seismometer, which is sitting on ground that is tilted 2 to 3 degrees. The first seismometer science data should begin to flow back to Earth after the seismometer is in the right position.

Several additional weeks will be needed to ensure the returned data are as clear as possible. Team members will check and possibly adjust the seismometer's long, wire-lined tether to minimize noise that could travel along it to the seismometer. Engineers also expect to command the robotic arm to place the Wind and Thermal Shield over SEIS to stabilize the environment around the sensors.

Assuming that there are no unexpected problems, the InSight team plans to deploy the HP^3 heat probe onto the Martian surface by late January. HP^3 will be on the east side of the lander's work space, roughly the same distance away from the lander as the seismometer.

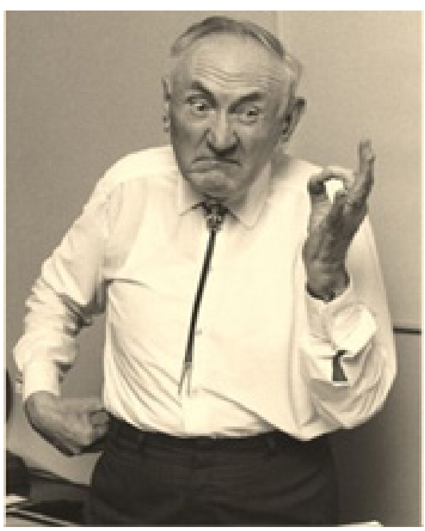
For now, though, the team is focusing on getting those first bits of seismic data (however noisy) back from the Martian surface. "We look forward to popping some champagne when we start to get data from InSight's seismometer on the ground," Banerdt added. "I have a bottle ready for the occasion."

JPL manages InSight for NASA's Science Mission Directorate in Washington. InSight is part of NASA's Discovery Program, which is managed by NASA's Marshall Space Flight Center in Huntsville, Alabama. Lockheed Martin Space in Denver built the InSight spacecraft, including its cruise stage and lander, and supports spacecraft operations for the mission.

A number of European partners, including France's Centre National d'Études Spatiales (CNES) and the German Aerospace Center (DLR), support the InSight mission. CNES provided SEIS to NASA, and DLR provided the HP^3 instrument. Spain's Centro de Astrobiología supplied the wind sensors.

Vera Rubin, Dark Matter, and Kitt Peak

By Ron Henke



Fritz Zwicky. Source: Flamseed.info

Although this article is about Vera Rubin, dark matter, and the National Optical Astronomy Observatories (NOAO) at Kitt Peak (a division of the National Science Foundation), this story really begins in the 1930s with Fritz Zwicky, a Swiss-born astrophysicist who taught at Cal Tech. (Zwicky was an interesting character who had some difficulty getting along with his colleagues, as the picture to left might suggest…he referred to them as "spherical bastards—anyway you look at them, they are still bastards.") In the 1930s, he was studying the motion of galaxies and noticed that they were moving too fast for the amount of mass that they had. He coined the term "dark matter" to describe the unseen mass propelling the galaxies. Not much attention was paid to his discovery at the time, but the term stuck.

Before Vera Rubin began her work on dark matter, she taught for a year (1954) at Montgomery Junior College in Maryland. From 1955 to 1965, she worked at Georgetown University (where she had received her PhD), holding various positions, including research associate, lecturer, and assistant professor of astronomy. In 1965, she moved to the Carnegie Institute as a staff member in the Department of Terrestrial Magnetism.

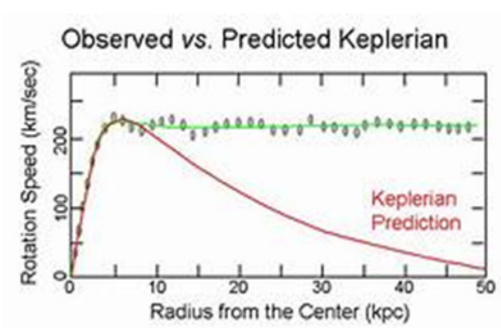
Rubin began her work on galaxy rotations in the late 1960s with fellow Carnegie staff member Kent Ford. (Author's note: The hot topic at the time was newly discovered quasars. However, as a woman of her time, she did not want to cause controversy, so she stayed away from that subject. Her gender proved an impediment until well into her career at the Carnegie Institute.) Rubin first studied movement of galaxies located away from the great attractor (a gravitational anomaly in the center of the supercluster of which the Milky Way is a part), but her conclusions were not well received. She and Ford then began studying galaxy rotation. Her first observations were made at the McDonald Observatory (University of Texas) and the Palomar Observatory in California. (She was the first woman to observe at the latter installation and had to create a woman's rest room because none existed when she applied there.)

2.1-m telescope at Kitt Peak

Vera Rubin using the 2.1-m telescope at Kitt Peak. Source: (NOAO)/AURA/NSF

Rubin did much of her research on dark matter using the 2.1-m telescope on Kitt Peak in southern Arizona, not far from Tucson. Her work there began in the early 1970s. The 2.1-m telescope was built by the NOAO for studies and research conducted by astronomers who were not associated with universities that owned their own telescopes, which was common at the time. She and Ford studied the rotation of the stars in the Andromeda galaxy and found that the stars in the core and the stars at the edge of the spiral arms rotated at the same speed. This became known as the "galaxy rotation problem" and went against Newtonian physics and the Keplerian Prediction. Either Newtonian physics and the Keplerian Prediction were wrong or something unknown was going on.

Rubin and Ford analyzed more than 200 spiral galaxies using the 2.1-m telescope and found the same galaxy rotation problem in all the galaxies observed. It was clear that something was not right with Newtonian physics and the Keplerian Prediction. After much thought and calculation, they determined that there must be a "gravity halo" of dark matter surrounding the galaxies holding them together, allowing the outer-most stars of a galaxy to rotate as fast as the core. These results were not widely accepted at first but as evidence continued to grow, dark matter and gravity halos became the accepted norm.



Source: Physics.stackexchange.com

The graph at left illustrates the discrepancy between the Keplerian prediction and a "typical" galaxy rotation curve of what is actually observed. As you can see, the Keplerian prediction fails miserably to explain the rotation curve observed, even though such Keplerian predictions work just fine for the rotation of planets in our solar system. The discrepancy is the evidence of dark matter.

Vera Rubin died on December 25, 2016, without being awarded a Nobel Prize in Physics. Sadly, because the Prize is not awarded posthumously, she will now never receive one.

Focus On: Apollo 16 Region—Descartes and the Cayley Plains

Jerry Hubbell

(Note from the author: A version of this article was published in the November 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 in this article, go to http://moon.scopesandscapes.com/tlo_back.html To see the latest issue of* The Lunar Observer, go to http://moon.scopesandscapes.com/tlo.pdf)

Figure 1. Apollo 16 Mission Patch, NASA.

This is the second in a series of Focus On articles in *The Lunar Observer* (TLO) on the Apollo lunar landing missions that will end on the 50th anniversary of the Apollo 11 mission in the July 2019 issue of TLO. To learn about the background behind this series of articles, see the October 2018 *StarGazer* Focus On article.

The Apollo 16 mission launched at 12:54 pm EST on April 16, 1972. The crew consisted of Commander John Young, Command Module Pilot Ken Mattingly, and Lunar Module Pilot Charles Duke (Figure 2).

Figure 2. Apollo 16 Astronauts. (from left to right) Ken Mattingly, John Young, and Charles Duke. NASA.

At Descartes, the Cayley and Descartes formations were the primary areas of interest because scientists suspected, based on telescopic and orbital imagery, that the terrain found there was formed by magma more viscous than that which formed the lunar maria. The Cayley Formation's age was estimated to be about the same as Mare Imbrium based on the local frequency of impact craters.

The landing site for Apollo 16 was in the Descartes Highlands region west of Mare Nectaris and the crater Alphonsus (Figures 3 and 4). The Cayley and Descartes formations are shown in Figure 5. Landing occurred on April 20, 1972 at 22:23:35 EST. The landing site is located at selenographic coordinates 8°58' south, 50°30' east, between craters Andel and Andel F (see Figure 4).

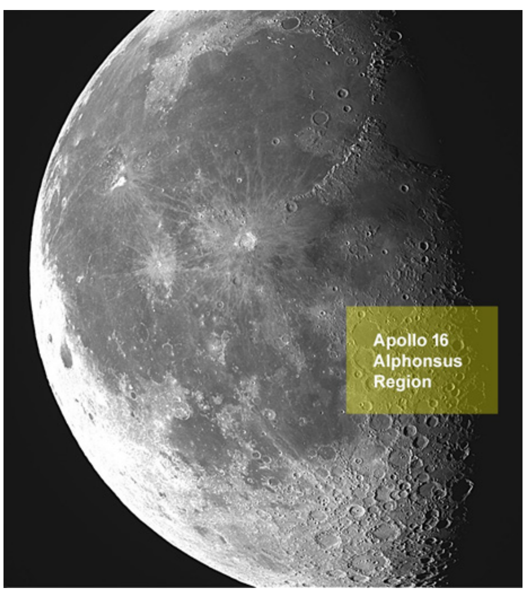


Figure 3. Apollo 16 Alphonsus Region—Third Quarter Moon, Jerry Hubbell, Wilderness, Virginia, USA. 30 October 2018 at 0730 UT. Colongitude 163.1°, seeing 7/10, transparency 3/6, 0.165-m APO refractor, 0.7x Focal Reducer, QHY174M-GPS TEC (deep-sky) Camera (ed. highlight label added)

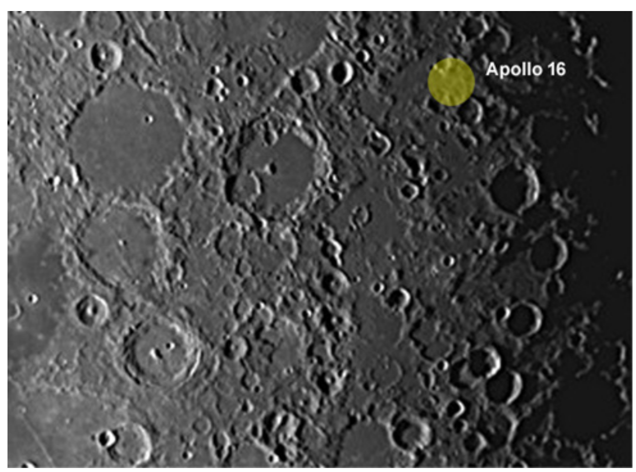


Figure 4. Apollo 16 Landing Site—Third Quarter Moon (ed. crop), Jerry Hubbell, Wilderness, Virginia, USA. 30 October 2018 at 0730 UT. Colongitude 163.1°, seeing 7/10, transparency 3/6, 0.165-m APO refractor, 0.7x Focal Reducer, QHY174M-GPS TEC (deep-sky) Camera (ed. highlight label added)

The Apollo Field Geology Investigation Team provided the following summary:

“The Cayley Plains at the Apollo 16 landing site (Figure 5) consist of crudely stratified breccias to a depth of at least 200 meters, overlain by a regolith 10 to 15 meters thick. Samples, photographs, and observations by the astronauts indicate that most of the rocks are impact breccias derived from an anorthosite gabbro complex. The least brecciated members of the suite include coarse-grained anorthosite and finer-grained, more mafic rocks, some with igneous and some with metamorphic textures. Much of the traverse area is covered by ejecta from North Ray and South Ray craters, but the abundance of rock fragments increases to the south toward the younger South Ray crater. The Descartes highlands, a distinct morphologic entity, differs from the adjacent Cayley formation more in physiographic expression than in lithologic character.”

There are several popular targets for observing and imaging in the Ptolemaeus, Alphonsus, Arzachel region of the Moon (Figure 6). For beginners, this is often one of the most recognizable areas of the Moon because it is right on the terminator at first quarter, probably the most popular time to observe the Moon. Rupes Recta, the “Straight Wall,” (Figure 7) is very easy to see and a favorite. Other large and small craters such as Albategnius, Klein, Hipparchus, Herschel, Abulfeda, and Delambre, just to name a few, are clearly visible in a small telescope and can be explored at your leisure when imaged.

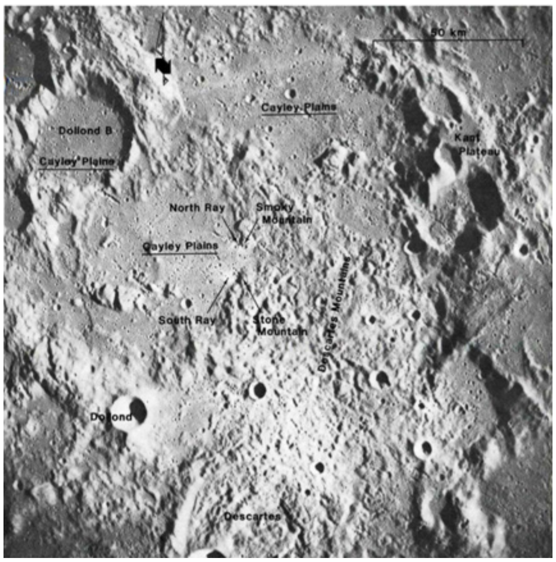


Figure 5. Apollo 16 Landing Site—Descartes and Cayley Plains, NASA Apollo Mission metric camera frame 439.

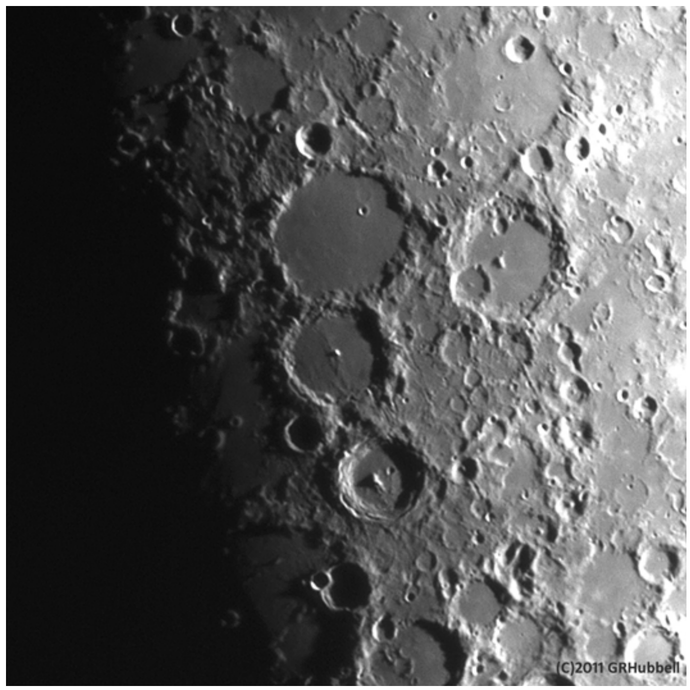


Figure 6. Ptolemaeus, Alphonsus, and Arzachel, Jerry Hubbell, Locust Grove, VA, USA, 03 March 2011 0217 UT, 0.13-m APO Refractor (Explore Scientific 5-inch ED APO), Imaging Source DMK21AU04 CCD, 4x Powermate. Seeing 8/10, Transparency 5/6, north/up, east/right.

Rik Hill contributed the following (refer to Figure 7):

“Often, we look too much at the terminator. A day or so after the terminator passed over this area there is still a lot to see. The first thing that stands out is the great terraced walls of Arzachel. Look carefully at the floor of this crater, and you'll see the Rimae Arzachel. Just above this is the larger crater Alphonsus with the obvious dark haloed volcanic features, some of the best such features visible to the amateur. Just to the lower left of Alphonsus is the interesting crater Alpetragius, with its round-mound central peak. Compare this peak to the one in Arzachel. The huge crater Ptolemaeus is the topmost of the three great craters here. At low sun angles, its floor is filled with soft depressions and small craters. Then to the lower left of this is the heavily eroded crater Davy and the arc of little craters crossing the floor. This crater chain is thought to be formed from the impact of a fragmented asteroid or comet broken up by Earth-Moon gravitational forces. This is like the S-L/9 impact on Jupiter but with the much slower rotation of the Moon leaving them in a much shorter chain."

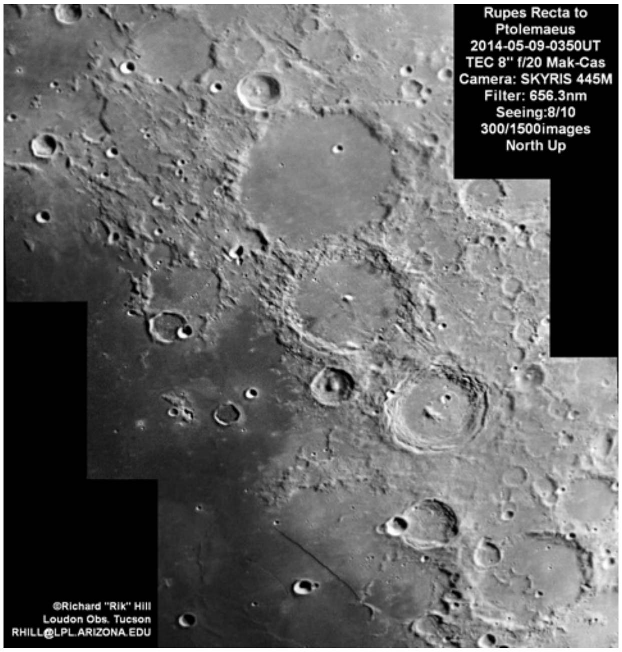


Figure 7. Rupes Recta to Ptolemaeus, Rik Hill, Tucson, AZ, USA, 09 May 2014 0350 UT, TEC 8-inch Mak-Cas Reflector, Skyris 445M CCD, 656.3nm Filter, seeing 8/10, north/up, east/right.

"At the bottom of this image [Figure 7] is clearly seen "The Straight Wall" or Rupes Recta. On the south end is what used to be called 'The Stag Horn Mountains.' They seem to have lost that name over the years."

"Lastly, back away and look at the whole glorious field and note the numerous diagonal gashes from the upper left to the lower right. These were carved out by mountain-sized and city-sized chunks of the lunar surface, blown out during the huge impacts that carved out the large mare to the north."

"The 4 images of this montage were each made by stacking 300 frames of 1500 frame AVIs taken with the equipment noted on the image. Assembly of the montage was done with AutoStitch and final processing was accomplished with IrfanView and GIMP."

Michael Boschat contributed the following (refer to Figure 8):

"I was just looking at the Moon's terminator using 140x and noticed that Alphonsus's central peak was catching the sunlight, and just near its base was a "halo" of sunlight just illuminating the crater floor. It was just an interesting observation, so I decided to try to get an image of the area. I used my Canon xsi with a 2x Barlow and took a series of exposures trying to get a decent image. I used the live view on the camera to focus the craters as sharply as possible. This was about the best image I could get. Also, I was shooting through my open apartment window and visually looking through the eyepiece—everything was sharp and clear with very, slight turbulence."

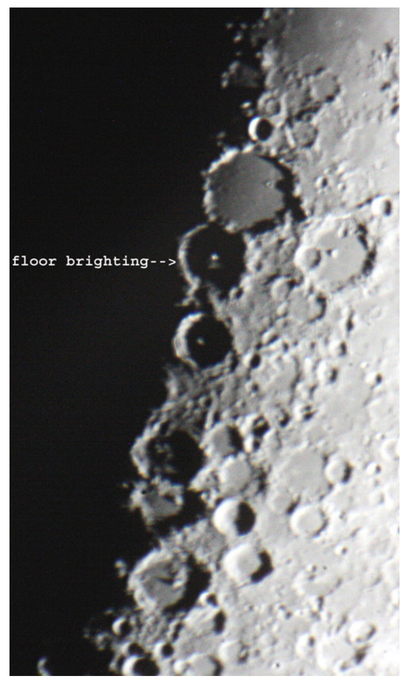


Figure 8. Alphonsus, Michael Boschat, Halifax, Nova Scotia, Canada, 27 October 2017 2158 UT, ETX 90mm Maksutov Reflector + 2x Barlow, Canon xsi DSLR. Seeing 8/10, transparency 4/6, north/up, east/right.

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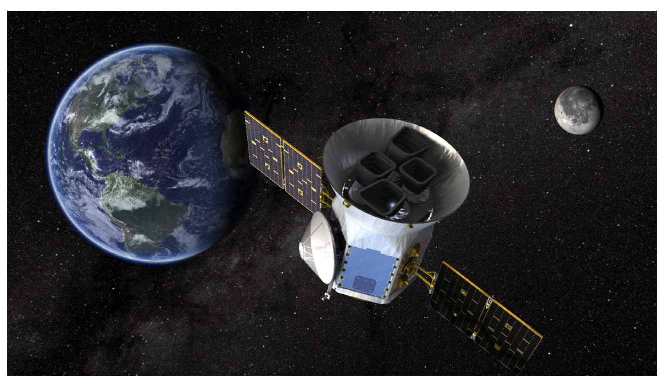
Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes
(Note: The club elections were held in November so there was no presentation that month.)

December 2018—The Transiting Exoplanet Survey Satellite Mission (TESS)


TESS and its four cameras. Source: NASA

Bart Billard's presentation discussed TESS, the recently launched NASA space telescope surveying nearly all the sky looking for nearby exoplanets. He said it was the next step after the Kepler Mission. For background and comparison with TESS, Bart began by revisiting a talk he gave about Kepler in March 2014. His talk included some NASA videos, starting with the April 18, 2018, launch of TESS on a SpaceX Falcon 9 rocket.

Bart said exoplanet discoveries started in the mid-1990s. Early planets were mostly Jupiter sized because their large mass made them easier to detect. Kepler was designed to monitor more than 150,000 stars continuously for 3-1/2 years or more using a 95-megapixel camera to detect brightness changes of as little as 100 parts per million. This precision, along with the mission length, were needed to detect planets similar to Earth in size orbiting stars similar to the Sun with periods like Earth's. Bart played a NASA video on detecting planets by transits. It showed how dips in the light from a star occur if a planet orbiting it passes between us and the star. Smaller dips indicate smaller planet size, and multiple dips can occur when more than one planet orbits a star. Bart showed a model of transit data, a "light curve" of a star with a sequence of smaller dips that could be an Earth-sized planet and a pair of larger dips that could be a Jupiter-sized planet. He said analysis of Kepler data showing more than one set of transits of a single star provides evidence that could be enough to confirm the transits were truly the result of planets orbiting the star. In some cases, the timing of one of the planet's transits could be seen to vary because of the gravitational influence of the other planet.

In February 2014, NASA announced verification of 715 planets in orbit around 305 stars. Prior to the announcement, there had been 2,823 additional candidate planets, many of which will also likely be confirmed.

Bart played another video illustrating the difference between the sky covered by Kepler and its K2 follow-up mission and the coverage TESS has. TESS has four cameras each covering a square area of 24 degrees on a side. These sky patches are arranged in a strip covering 24-by-96 degrees. TESS began covering the first 24-by-96-degree strip, called a sector, last July. Each sector is covered for about 27 days before the telescope moves on to the next sector. After covering 13 sectors south of the ecliptic plane in the first year of its mission, TESS will begin covering the sky north of the ecliptic plane in the second year. The sectors overlap at the ecliptic poles to allow continuous coverage of a part of the sky. The total area covered will be 350 times that covered by Kepler and K2. Bart showed a map of the TESS sectors covered in the first year on a grid showing celestial coordinates. Sector 6, which TESS began monitoring in early December, is the sector farthest north of the celestial equator. Along with its two neighbors, Sector 6 will be the most likely to produce targets we can observe from our latitude during this first year. Another video showed the orbit of TESS and how it was achieved with a “gravity assist” from the Moon. The orbit has a resonance of 2 orbits to 1 with the Moon’s and thus is very stable.

The last topic was the TESS Follow-up Program. Amateur observers can contribute with observations on the ground to resolve ambiguities in TESS survey candidates. The resolution of the TESS cameras results in a photometric aperture of about 2 arc minutes. That aperture could include several stars, requiring additional ground-based observations to identify which of the “blended” stars was responsible for the apparent transit signal. Some signals could actually be caused by a background eclipsing binary system blended with foreground stars. Amateur light curves could reveal this as a deep transit signal in the fainter background star system, as opposed to a shallower planet-like transit in a brighter blended star. Bart illustrated how follow-up observations such as the exoplanet light-curve measurements he and Jerry Hubbell have done can provide parameters of a particular exoplanet system. A screenshot from the Exoplanet Transit Database website illustrates an observation they made of the system HAT-P-30/WASP-51 b after fitting it to a transit model with tools provided by the website. It showed the derived planetary radius was in fairly good agreement with the catalog value, and the derived orbital inclination had quite good agreement. Inclinations for planet transits near the center of the star’s disk have flatter-bottomed light curve dips than planet transits near the limb of the star. Bart showed results of AstroImageJ analysis of a recent observation Jerry made from MSRO. The data fit the model transit light curve nicely, and the scatter of the individual measurements was less than .003 of a magnitude.

Bart wrapped up with another TESS video showing data from the testing phase of TESS last summer. TESS captured NEOWISE Comet C/2018 N1 and other interesting features. The comet’s tail changes direction, some variable stars blink, and when the video is sped up at the end, numerous asteroids are picked up moving among the stars. This presentation is posted online at the RAC website.

Joe Garcia asked whether orbital planes are randomly oriented and whether there were any planets around binary stars. Bart said the Kepler discoveries were consistent with the proportion of stars expected for random orientation. He also thought molecular clouds that collapse and become star-forming regions appear to clump up from influences such as supernova explosions, and the resulting turbulence seems likely to randomize the orientations. He said the first discovery of a circumbinary exoplanet was made by two participants in the Planethunters citizen science project that lets users apply their pattern recognition skills to light curves of Kepler data.

Ryan Rapoza asked how big the TESS satellite is. Bart went back to the slide showing the satellite image with the arrangement of the four cameras and another image of one of the cameras in the laboratory with people suited up to prevent contamination working on it. We concluded it was somewhere near the size of a washing machine.

Joe asked about typical orbital periods and how hard it was to predict the next transit. Bart noted that Kepler required at least two transit detections, four for planets near Earth size, so the periods could be found from the time between transits. Afterward, he spoke with Joe and learned he was thinking of how follow-up observations would be done if TESS detected only one transit of a star. It was a good question because TESS is only spending about 27 days on each sector (except for the continuously observed areas at the ecliptic poles) for the first 2 years. However, Jerry and Bart had indicated that fitting a transit model to a light curve can provide some indication of the orbital period.

Don Clark asked whether the Hubble Space Telescope could be used to confirm exoplanet candidates from TESS. Bart thought it could be used to resolve ambiguity for blended stars or for detecting a blended eclipsing binary false positive. He thought radial velocity observations would need to be made with ground-based telescopes and that adaptive optics telescopes would also provide some of the high-resolution imaging need for blended stars. Don also asked how you determine planet size. Bart said the transit depth depends on the planet's area compared with the star's area.

January 2019—New Astronomy Gear Workshop

The program for this meeting was "New Astronomy Gear Workshop." Amy and Rich Lieberman brought in some equipment that Rich said had belonged to his late father. He said he went to New Mexico to sort through his father's collection and tried to pick a couple of items that looked the least complicated and most likely not to require some other item in the collection that he was unprepared to identify. His gear included a Sky-Watcher 4-inch ED refractor telescope and a giant set of binoculars. Glenn Holliday said Sky-Watcher telescopes were generally somewhat higher quality than Celestron telescopes. Scott Busby looked inside the case and found 5-mm and 20-mm 1-1/4-inch eyepieces, a 2-inch diagonal, and a finder with a right-angle eyepiece. Rich also had a tripod, but it lacked a head and did not seem sturdy enough for the refractor. Scott B. suggested Rich would need to get an altitude/azimuth mount with a Losmandy dovetail clamp, and that OPT could tell Rich what mounts fitting that description were available. He also suggested choosing a non-computerized mount. Scott Lansdale brought up the need for considering the weight limit of the mount. Scott Busby estimated that the chosen mount would need to be able to carry 40 pounds and mentioned he prefers to find used equipment, recommending Astromart and Cloudy Nights as good websites for finding used astronomy equipment.

Next we looked at the binoculars Rich brought. Again, they would need some sort of mount to help steady the views. Someone mentioned getting a tripod with a pan/tilt head. Bart Billard described the stand he built from a kit he saw at a Northeast Astronomy Forum meeting a few years ago. He said he would email Rich after the meeting to tell him the name of the kit and the source. Rich was unsure whether he and his wife would want to invest enough for a mount for the Sky-Watcher refractor. We suggested starting with the binoculars would be a good idea for getting a feel for their interest in astronomy. Scott Lansdale suggested they might be able to arrange to use the Sky-Watcher with a borrowed mount at a star party. Others suggested Myron Wasiuta was likely to have one. Scott Busby judged the refractor was in pristine condition and that it could sell for 20 percent below retail (maybe even 15 percent), if Rich and Amy decided to sell it. Rich indicated he thought the idea of starting with the binoculars was a good one.

Rolando Pancotti said he was having trouble using a laser collimator with his small Orion reflector telescope. Glenn Holliday encouraged him to take them to the next star party. He said before sunset was the best time to get help with collimation.

Image of the Quarter

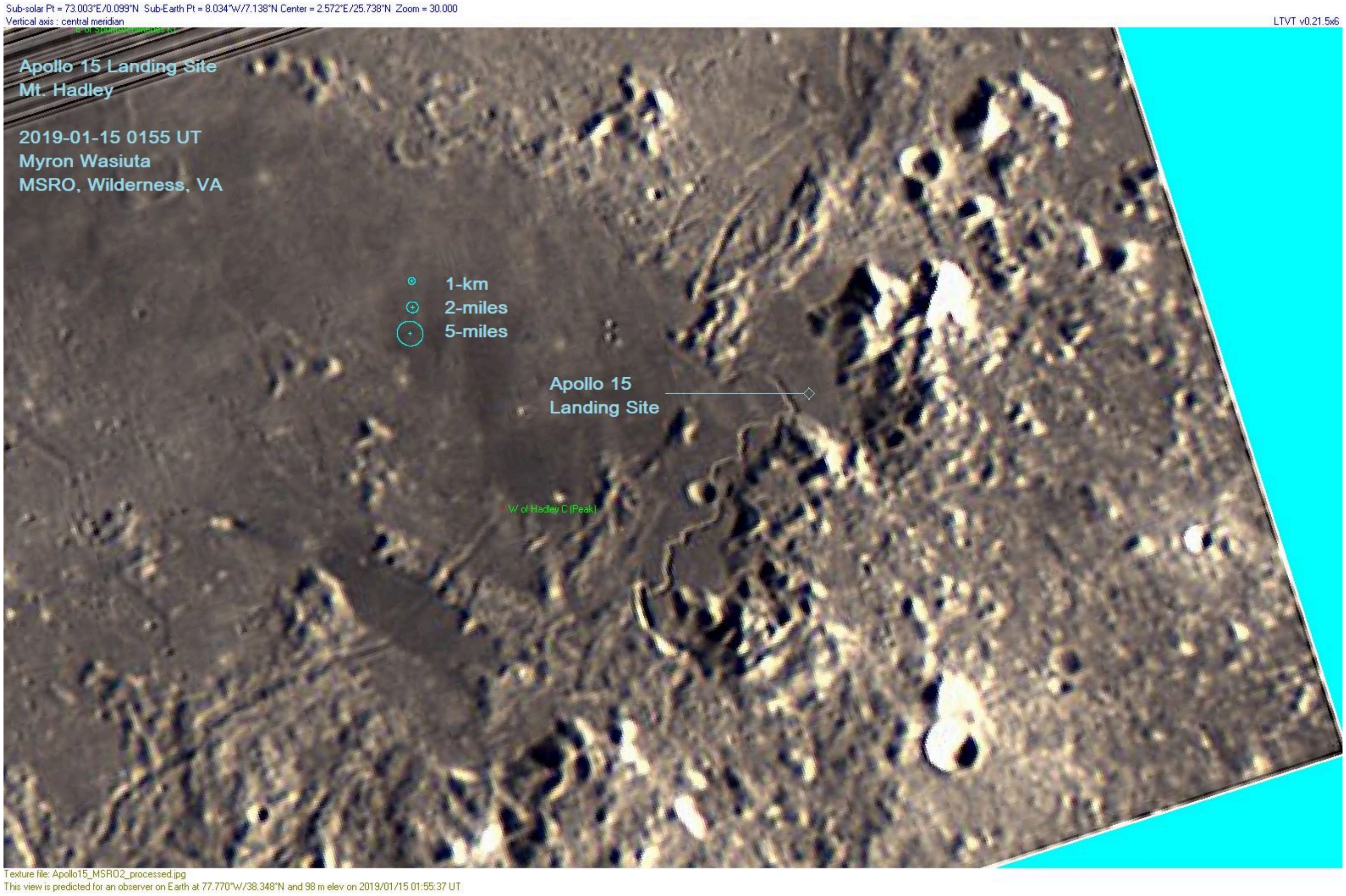


Image taken by Myron Wasiuta (see details in the label on the photo). Myron commented that this image was one of the best ones he'd ever taken of the region. The blue scale indicators show what an amazing close-up this is, showing details as small as 1 km in diameter.