http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 1, Vol. 7 May 2018–July 2018

How to Make a Moon

by Glenn Holliday


Theia, a Mars-sized protoplanet, collides with the young Earth. Credit: NASA/JPL-Caltech

In my first college physics class in 1973, a professor told us about quarks—"if they exist." I continue to love that uncertainty in science. Every theory must admit, "Of course, I could be wrong." When we want to be careful, we use the label "theory" only for something that is falsifiable. And we choose the best theories by examining the competition.

Here's a wonderful example in astronomy. How was our Moon formed? Most of us know about the Giant Impact theory: a planet-sized object hit the Earth, causing a large splash of material from both objects that coalesced into the Moon. This is—to be fair—the dominant theory of how our Moon was formed. Most astronomers will say the Moon was most likely formed by a giant impact. However, agreement between theory and measurements is not nearly as good for the Giant Impact theory as it is for, say, the theory of orbital mechanics.

There are a half dozen competing theories. Each is still studied because it better explains some part of the data than do any of the other five theories. One of these competing theories could become the future most-favored theory for the formation of our Moon.

So, what do you need to make a moon? Here are six different recipes you could use to do it.

Recipe #1: Whack It Out of the Earth

This is the Giant Impact theory. Proposed in 1947, it took a few decades to catch on and replace the older favorite in the hearts of astronomers. Start with the leading theory of star formation: A star condenses from a cloud of gas and dust, which becomes a protostellar disk. After the star ignites, the remaining material is a protoplanetary disk. Many objects clump together in this disk. An important bit is that the disk is crowded and so protoplanets frequently collide with each other. This is how they aggregate into larger planets. As planets form, they gradually use up the available material. The frequent collisions end when the solar system is no longer so crowded. When the Earth is only about 100 million years old, it collides with another protoplanet, perhaps as large as Mars. The impact throws lots of matter from both objects into orbit. It heats both objects. Both probably have melted crusts, and both may be completely melted or even vaporized. Material from both objects gets mixed into the resulting Earth. Heavier material ends up at the center of the Earth, and lighter minerals form a ring that takes some time to coalesce into the Moon. In fact, this may have created multiple protomoons for a while until they collided to form the final object we know as our Moon. (continued on page 5)

How to Join RAClub

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

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

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

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

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

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Yahoo Group:
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Calendar of Upcoming Events

RAC Picnic, Belmont	August 11*
Embrey Mill Star Party, Stafford	August 17
Star Party, Caledon State Park	September 8**
Star Party, Caledon State Park	October 6**

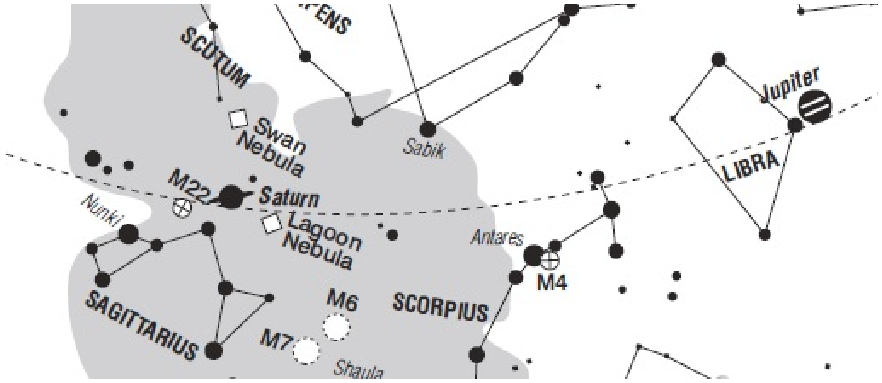
Recent Outreach Events Completed

Star Party, Caledon State Park	July 7

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

President's Corner

Welcome back to another great edition of the *StarGazer* newsletter.



Portion of the sky selected from **WhatsOutTonight.com**

Several good articles highlight recent activity by the club members. As always I like to focus on the outreach and Caledon star parties. The weather was finally cooperative on July 7 (after both May and June's star parties were "weathered out"). After Glenn Holliday presented his program titled "How to See Nothing: Black Holes," nearly 20 guests enjoyed the night sky at Caledon State Park in King George, VA. Observing focused in and around the constellation Sagittarius, where we observed M6, M7, M22, and Lagoon and Eagle nebulas. Also observed elsewhere were Jupiter, Saturn, and galaxies M81/82. Overall, it was a great night out at Caledon, and I encourage all observers to join us in September and October for more great observing. Bring your own telescope or enjoy views through ours.

Clear Skies, Scott Lansdale

Astronomy Math: The Doppler Effect
by Scott Busby

I know you've already heard about the Doppler effect and should be somewhat familiar with it. You may have experienced the changing pitch of a siren from an ambulance as it moves past you. Although sound waves and light waves are very different, the Doppler phenomenon occurs in both cases: when the source of waves is approaching you, the wave compresses and the wave's crests and troughs arrive more frequently. So in this case you measure a shorter wavelength and a higher frequency than the true values. Conversely, if the source of the waves is moving away from you, the waves are stretched out, and the wave's crests and troughs arrive less frequently than if the source were stationary. So for a receding source, you measure a longer wavelength and a lower frequency then the true values.

Because blue light has a shorter wavelength and higher frequency than red light, the light from approaching objects is said to be "blueshifted," and the light from receding objects is said to be "redshifted." In astronomy, this terminology is used even if the waves are not in the visible portion of the spectrum—a shift toward longer wavelengths is called a redshift and a shift toward shorter wavelengths is called a blueshift even if the waves are radio waves or X-rays. The Doppler effect also occurs when it's you (the observer) who's moving rather than the source—if you're moving toward the source, its light will appear blueshifted, and if you're moving away from the source, its light will appear redshifted. All that matters is the relative speed between you and the source. In the next newsletter, we will explore the Doppler equation and its alternative forms.

The Doppler equation

$$\frac{\lambda_{app}}{\lambda_{true}} = 1 + \frac{v_{rec}}{c}$$

Classroom Training for the Mark Slade Remote Observatory (MSRO)

August 4, 2018, 10 am–noon: The MSRO Commission is sponsoring a get-together at the Wilderness Branch of the Orange County Library at 6421 Flat Run Road in Locust Grove, VA, to introduce the launch of the MSRO Training Program. The MSRO is an advanced, state-of-the-art small telescope observatory that can be remotely operated over the Internet from your home computer.

The program is free to members of the RAClub (RAClub.org) and to new members joining to take advantage of this opportunity. The meet-and-greet will allow prospective students to find out more about the training to be conducted at the library and on-site at the observatory 3 miles away. The training is scheduled to start Saturday, September 1.

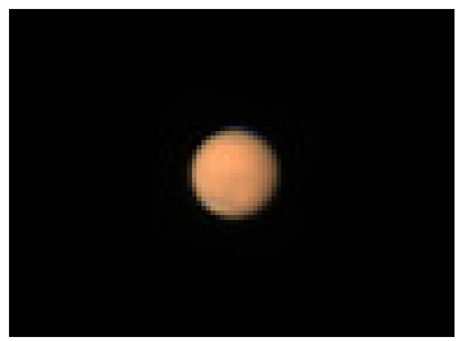
The training will be given by MSRO Director, Dr. Myron Wasiuta, and MSRO Assistant Director, Jerry Hubbell, and will consist of two 5-hour Saturday sessions (including lunch breaks). Myron has extensive experience observing the night sky and operating an array of amateur and professional-level equipment, having taught astronomy at the University of Mary Washington and done work at the United States Naval Observatory in Washington, DC. Jerry has been an amateur astronomer since the 1970s. Over the past 10 years, he has worked with advanced amateur astronomical imaging equipment and written two books on scientific imaging and remotely operated observatories.

For more information about the observatory, visit the RAClub website at RAClub.org/MSRO, and you can find information on how to join RAClub on page 2 of this newsletter. If you plan to attend and/or have questions, please email MSRO@raclub.org

Curiosity: Unprecedented Opportunity to Photograph Martian Dust Storms

By Linda Billard

As you probably have read—and some of you have observed first-hand through your telescopes—a record-breaking dust storm has engulfed much of Mars just it approached opposition. This opposition is the closest in 15 years but the storm has made the "close-up" disappointing for astrophotographers. The storm began in mid-June and has intensified to the point that NASA has suspended the science operations of the Mars rover Opportunity. Opportunity is powered by the Sun, which is totally obscured by dust. However, the Curiosity rover, which has been studying Martian soil at Gale Crater, is expected to remain largely unaffected by the dust. It has a nuclear-powered battery that runs day and night.



Mars, July 9, 2018, 2 02:31AM EST Seeing average. Scope: FRC300. Camera: ZWO ASI120MC. 2X Meade extender. Credit: Scott Busby

Comparison image of Mars taken June 25, 2016. Credit: Scott Busby

Since mid-June, the dust has steadily increased. The sunlight-blocking haze—referred to as "tau"—was more than 8.0 in early July at Gale Crater—the highest tau ever recorded by the Curiosity mission. In contrast, the tau last measured over Opportunity was near 11, which had made accurate measurements no longer possible for Mars' oldest active rover. The photos at right, taken by RAC member Scott Busby on July 9 this year and June 25, 2016, show how obscured the surface has become, although Scott thinks things may be improving because some details are visible that weren't previously. (The brighter area in the lower right quadrant is likely Hellas Planitia.)

For NASA, Curiosity offers an unprecedented "opportunity" (pun entirely intended) to answer some key questions about Martian dust storms, including why some (like this one) last for months and grow massive, while others stay small and last only a week.

Scott D. Guzewich, an atmospheric scientist at Goddard Space Flight Center, is leading Curiosity's dust storm investigation. He points out that

Curiosity, as well as a fleet of orbiting spacecraft, will facilitate collection of dust information from both the surface and space. The last Mars dust storm of similar magnitude was in 2007, 5 years before Curiosity landed there.


Curiosity image taken on Sol 2104 (July 7, 2018). Credit: NASA/JPL-Caltech/MSSS

Daily photos captured by Curiosity's mast camera (mastcam), have shown the sky as it gets hazier. This sun-obstructing wall of haze is about six to eight times thicker than normal for this time of season. The accompanying image shows a mastcam view. The nearby terrain is clearly visible; however, no detail can be seen beyond the foreground, and the entire scene is murky red-brown owing to the dust storm.

Curiosity's engineers say the storm poses little risk to the rover's equipment. The greatest impact is on its cameras, which require extra exposure time because of the low lighting. To reduce the dust blowing at its optics, Curiosity routinely points its mastcam down at the ground after each use.

As of mid-July, unhampered by the storm, Curiosity is going about its mission, heading back toward a site visited on Sol 2005 within the "great red spot" (on Mars, not Jupiter), where it will continue its soil-sampling activities in an area believed to have large deposits of hematite, which is red.

How to Make a Moon (continued from page 1)

Recipe #1 Advantages

- This recipe explains why there are both some chemical similarities and some chemical differences between the Earth and Moon.
- It also explains why the Moon's orbit aligns with Earth's spin.

Recipe #1 Disadvantages

- The theory predicts that multiple moons are a more likely result than our single moon. Also, because the other rocky planets (Mercury, Venus, Mars) were forming at the same time under the same conditions, the theory predicts similar events to form moons for them. But that did not happen. Earth's Moon has a number of characteristics unique among the moons we know in our solar system.
- Some astronomers believe the complete liquifaction or vaporization of Earth was unlikely and favor a lower energy impact. But without the complete mixing of material from both colliding bodies, the theory predicts the Moon would have a chemical composition much different than the Earth—and different than what we actually measure.
- A high-energy impact also puts much more energy into the Earth–Moon system, which results in a faster spin of both objects than we actually measure (although there are other theories about how the total angular momentum of Earth and Moon affected spin velocities and orbital velocities over time).

Recipe #2: Hit the Earth Many Times

This is a variant that eliminates most of the disadvantages of the Giant Impact theory. The Earth's early orbit was cluttered with many relatively small protoplanets. Many small collisions are more likely than a single giant collision. (Note that this happens during a period long before the more famous Late Heavy Bombardment.) Each collision contributes some partial mixing of material with different chemical composition than the Earth and also throws off some debris into orbit as rings with a combination of material from Earth and the impactor. Over time, the Earth's rings coalesce into our Moon.

Recipe #2 Advantages

- This recipe explains the chemical similarities and differences between the Earth and Moon while also explaining their spin velocities.

Recipe #2 Disadvantages

- ❖ The theory fails to explain why other rocky planets did not form similar moons.

Recipe #3: Steal Someone Else's Moon

We have evidence that some of the other planets in our solar system captured moons that originally orbited other objects. All of the other moons around the rocky planets in the inner solar system (Mars' Phobos and Deimos) appear to be captured objects. Maybe Earth did this, too. One variant of this theory suggests that our Moon originally formed around Venus.

Recipe #3 Advantages

- ❖ Orbital transfer could happen at lower energies than giant impacts.

Recipe #3 Disadvantages

- ❖ A moon originally made someplace else probably would not be as similar to the Earth as our Moon is.
- ❖ The moons we think were captured by other planets are generally much smaller than our Moon. Many also have eccentric orbits compared with our Moon.

Recipe #4: Spin the Earth Fast Enough to Tear It Apart

A century ago, most astronomers would have told you the Moon was most likely formed by fission from the Earth. This was the first serious theory advanced, and it was the leading theory from the time of its publication in 1898 until the Giant Impact theory became more favored in the 1970s. It starts with an older theory of planetary formation in which only a single body formed in the orbit of the Earth rather than many smaller protoplanets and chunks of planets. In all of these theories, the young Earth forms hot, probably completely molten at first. As the Earth cools, it remains soft and plastic for a long time. The centrifugal force generated by the Earth's spin is greater than the rigidity of the soft body, and the Earth splits into two bodies. The young Moon formed in a very close orbit. Tidal forces then slowed down the Earth's spin and enlarged the Moon's orbit.

Recipe #4 Advantages

- ❖ This recipe explains the similarities in the chemistries of the Earth and Moon.

Recipe #4 Disadvantages

- ❖ This theory does not explain the differences in the chemistries of the Earth and Moon.
- ❖ The spin velocity of the young Earth necessary to produce enough force to spin off the Moon is faster than any model of planet formation predicts.

Recipe #5: Condense the Earth and Moon Together

In the Earth's orbit in the original protoplanetary disk, the dust and other matter condensed into a single region. The resulting cloud of stuff that was becoming the Earth was large enough that it condensed into two objects rather than one—Earth and Moon. The two were close enough to remain gravitationally bound.

Recipe #5 Advantages

- ❖ This recipe explains the similarities in the chemistries of the Earth and Moon.

Recipe #5 Disadvantages

- ❖ This theory does not explain the differences in the chemistries of the Earth and Moon.
- ❖ It does not explain the high total angular momentum of the Earth–Moon system, which resulted in the Moon's modern orbit.
- ❖ It predicts the Earth and Moon would have similar proportions of core, mantle, and crust. In fact, the Earth's core is proportionally much larger compared with its overall size than the Moon's core is to its overall size.

Recipe #6: Aggregate the Earth and Moon Together

This recipe says that condensation and gravitational collapse in the Sun's protoplanetary disk produced many small protoplanets, planetoids, and clumps of rock. Collisions between all these small objects produced a small number of larger planetoids. But unlike the Giant impact theory in which a Mars-sized object collided with Earth, in this theory, a Moon-sized object passed close enough to be captured by Earth's gravity and enter orbit.

Recipe #6 Advantages

- This recipe explains why this arrangement happened by chance for Earth but not for the other rocky planets.

Recipe #6 Disadvantages

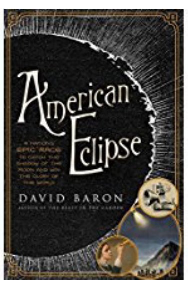
- This theory does not explain the ways the chemistries of the Earth and Moon are similar.
- It does not explain the angular momentum of the Earth–Moon system and the Moon's orbit.
- This type of gravitational capture is more likely to produce a more eccentric orbit than the Moon has.

As with all things in astronomy, and in the rest of science, the best question is not which theory you choose to believe, but which theory best fits the facts. Unlike some other examples where we have theories with very good agreement with all the data, the theory of how the Moon was formed is likely to see more research and development for some time yet.

Book Report: *American Eclipse* by David Baron

By Scott Busby

In 1878, the Moon's shadow descended on the American West, darkening skies from the Montana Territory to Texas. This rare celestial event—a total solar eclipse—offered a priceless opportunity to solve some of the solar system's most enduring riddles and prompted several enterprising scientists to brave the frontier in a grueling race to the Rocky Mountains. Science journalist David Baron, long fascinated by eclipses, recreates this epic tale in *American Eclipse*.



American Eclipse describes the intense competition that dominated late 19th-century American astronomy, revealing the challenges faced by three of the most determined eclipse chasers who participated in this adventure. James Craig Watson, a renowned asteroid hunter who fantasized about becoming the next Galileo, hauled a telescope, a star chart, and his long-suffering wife west in attempt to discover Vulcan, a hypothesized "intra Mercurial" planet hidden in the Sun's brilliance. Vassar astronomer Maria Mitchell, who, despite obstacles erected by the male-dominated astronomical community, charged west with a group of female students to observe the eclipse for themselves. Finally, Thomas Edison braved the wilderness to prove himself to the scientific community. Armed with his newest invention, the "tasimeter," he sought to leverage the eclipse to cement his place in history.

With vivid accounts of train robberies and Indian skirmishes, this book not only brings to life the mythologized age of the Wild West but memorializes an historical eclipse that came to symbolize American science in its ascendance.

I often wax nostalgic when reading about early astronomical research by American astronomers. We were always on the verge of some amazing discovery or gaining incredible knowledge that helped us to understand the nature of our solar system and the universe in general.

American Eclipse describes this very thing, exploring the historical perspective of late 19th-century and early 20th-century astronomical research and the challenges early American astronomers endured to establish themselves in academia.

American Eclipse kept me glued to its pages. It made me remember that while I was in elementary school, we were given a project to design a planet in a star system and to present and describe our planet to the class. I constructed my planet out of a styrofoam ball from the local craft store. Using a styrofoam ring, some stiff wire, and colored markers, I fashioned a ring around my planet and even attached a single moon. I described my planet as barely inhabitable because of its proximity to its star. It was a desert planet that I fondly called Vulcan. I selected the name after intensive research into Greek mythology. I wanted to stay with the naming conventions of our own solar system's planets. Amazingly, only a few years later the imaginary planet Vulcan emerged as Mr. Spock's home world in the TV series *Star Trek*. Many years later, I discovered that astronomers of the 19thcentury actually hypothesized that such a planet resided inside the orbit of Mercury in our own solar system, but it was too close to the Sun to be visible.

American Eclipse sent me back to that time in my life when astronomy was emerging as a science I was truly interested in. To this day, I remain so.

U.S. Record-Holding NASA Astronaut Retires

By Linda Billard

NASA astronaut Peggy Whitson, who holds the U.S. record for most cumulative time in space, retired on June 15. Whitson started her career with NASA in 1986 as biochemist. She applied to be an astronaut 10 times before being chosen, serving on her first space mission in 2002.

As an astronaut, Whitson completed three long-duration missions to the International Space Station, setting records on each. She made her first trip in 2002 as part of Expedition 5, during which she took part in 21 science investigations and became NASA's first space station science officer. In 2008, Whitson returned on Expedition 16 and became the first female commander of the space station.

During her most recent mission, spanning Expeditions 50, 51 and 52 from November 2016 to September 2017, Whitson became the first woman to command the space station twice (Expedition 51). She also claimed the title for most spacewalks by a woman—10 spacewalks totaling 60 hours and 21 minutes—and set the record for most time spent in space by a U.S. astronaut at 665 days. This is the equivalent of a hypothetical round trip to Mars!

Whitson's time on the ground at NASA was no less groundbreaking. She served as chief of the astronaut corps from 2009 to 2012, becoming both the first woman to hold the position and the first non-military astronaut corps chief.

"I have hit my radiation limit," she said during a recent interview. "So I'm not going into space with NASA anymore." This is both sad and exciting for Whitson, who half-jokingly admits she's still not sure what she's going to do "when I grow up"—an ironic statement from someone who has logged more time in space than any other American and was the first woman to command the International Space Station.

FOCUS ON: The Straight Wall—Rupes Recta

By Jerry Hubbell

(Note from the author: A version of this article was published in the April 2017 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)*

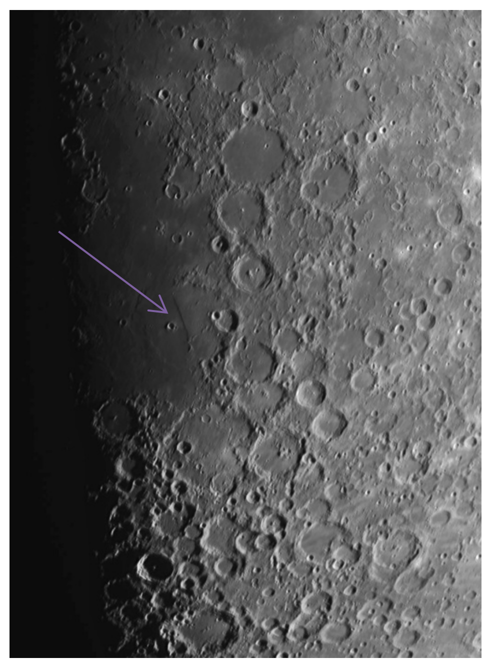


Figure 1. RUPES RECTA, Starkville, MS, October 10, 2016—David Teske, 00:19 UT. Questar 3.5" Maksutov, Mallincam GMTm CCD, Clear Sky, Seeing 6/10.

Object 15 on Chuck Wood's Lunar 100 list of lunar features to observe—the Straight Wall, aka Rupes Recta or "straight cliff"—is located at selenographic coordinates 22.1°S 7.8°W. It is 85 mi (134 km) long and about 1,600 ft. (0.49 km) high. In my younger days, no other feature captivated me more than this thin, linear scarp on a near-perfect lava plain of a ghost crater. Crater Thebit lies 60 mi (100 km) to the east, and crater Birt lies only 15 mi (24 km) to the west.

Located almost directly 400 mi (650 km) north of the crater Tycho, the Straight Wall is very easy to spot a couple of days past first quarter (Figure 1). It is on the eastern edge of Mare Nubium (Sea of Clouds) northwest of the southern lunar highlands.

One of the most studied aspects of the Straight Wall is how steep the slope is. The LAC Chart 95 Purbach shows a good representation of the Straight Wall and lists a height of about 1,300 ft. (400 m) above the surrounding lava plain. Figure 2 shows a Lunar Terminator Visualization Tool (LTVT) measurement of an image of Rupes Recta early in the morning.

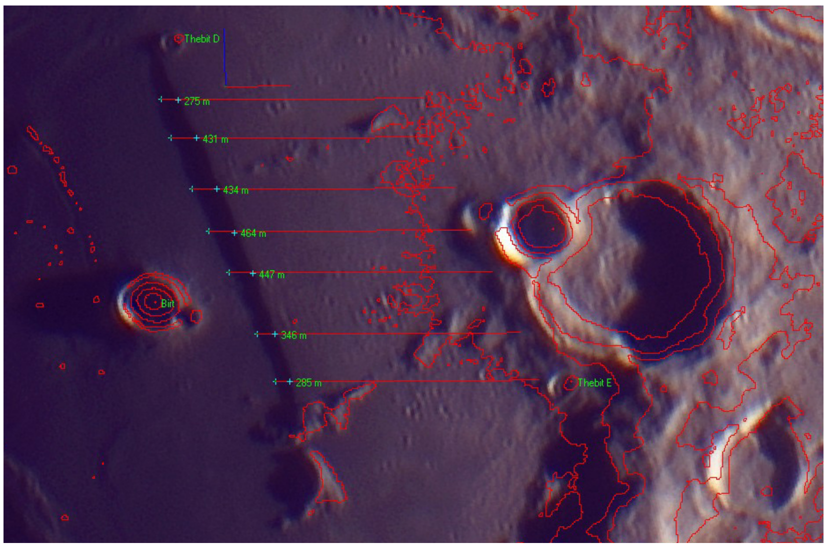


Figure 2. RUPES RECTA, Carrizozo, NM, September 10, 2016—John Duchek, 03:00 UT. Skywatcher Mak-Cas, ZWO-178MC CCD, Seeing 6/10, Transparency 5/6. LTVT Measurement by Jerry Hubbell.

The measured height of Rupes Recta directly east of Birt in Figure 2 is very close to that listed on the LAC chart, 1,370 ft. (410 m). At a little above 1,430 ft. (431 m), the measured value is about 5 percent higher, or about 60 ft. LTVT makes a very accurate measurement based on the date and time of the observation and the location of the observer. It is satisfying to be able to perform an independent measurement and repeat the prior work done to validate the technique. The measurements range from 1,550 ft. (464 m) near the center of the cliff to about 920 ft. (275 m) near each end. To evaluate the error, several independent measurements at each point would need to be performed on several photographs at different lunations; however, with the co-longitude near 11°, the shadow length provides an opportunity to achieve a high level of accuracy.

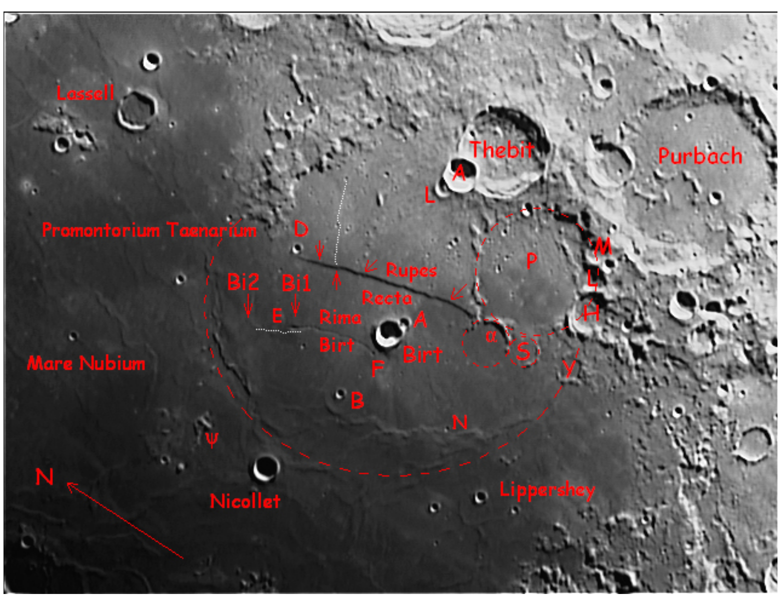


Figure 3. RUPES RECTA, Madrid, Spain, January 13, 2011—Alberto Martos, 02:59 UT. Newtonian 20 cm F/7.2 Barlow x2, Philips TouCam Pro CCD, Seeing 7/10, Transparency 4-5/6.

Alberto Martos describes his image of the Straight Wall (Figure 3) as follows:

"Effectively, Rupes Recta is the most famous Moon cliff, although its true nature and physical form are far from the image that our eye catches and our brain represents. Its true nature is a fault scarp 110 km long that runs approximately north-south across eastern Mare Nubium. The slope is step down from east to west, a configuration that explains the darkness of the fault face under easterly illumination and its brightness under westerly illumination, when the slope is step up and the exposed foot of the scarp is lightened by sunlight. As far as the transversal and vertical measurements are concerned, officially 2.5 km wide and up to 300 m tall (A. van den Bohede, TLO Jan. 2005), the slope is far from what typifies a steep abyss, yet there exists a whole assortment of height data obtained by different authors (R. Lena *et al*. in *Selenology Today*, vol. 10, June 2008). Measurements in that publication range from a maximum of 495±20 m near the center of the scarp, to about 300±30 m near the tips, while the width is recurrently 1.28±0.07 km from beginning to end. The subsequent maximum slant is about 21 degrees, a very gentle one." This description agrees with the value for the cliff listed in the LAC chart. This validates the measurements done on Figure 2, with a bias, or offset value of about -100 ft. (-30 m) for the measured values in Figure 2.

It is important to keep in mind that repeating topographical measurements that have been performed by the professionals is a way to gauge your skills and knowledge and provide an independent check on your technique. This example shows that it is important to make sure you accurately record the date and time and location of your observations so that any measurements can be repeated by others.

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Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

May 2018—Red, White and Blue Stars

APOD, February 22, 2015. River to Antares. Credit and copyright: Jason Jennings

Glenn Holliday said that his presentation was a version of a talk he gave at Caledon for one of the scheduled star parties. He first discussed the source of the different star colors, the different black-body spectra for different temperatures. He said stars have different temperatures because of their mass. Stars with more mass have higher pressure to balance the greater gravitational force pulling all of the gas in them toward the center. The higher pressure also results in higher temperature and faster fusing of hydrogen into helium. The lower mass stars have longer lifespans. Glenn said most red stars are red dwarfs, but they are not easy to see compared with red giants like Antares. He showed an image of Antares that resolved patterns on its surface. He said "carbon stars" are especially red. They are stars that have produced a lot of carbon from fusion of their lighter elements. R Sculptoris is an example.

Glenn used Sirius as an example of a blue giant star. He also pointed out the white dwarf companion in the Sirius picture, noting that white dwarfs are truly white, and the Sun is yellow by comparison. Glenn said he was not sure but thought that most white stars are white dwarfs. They make planetary nebulae glow, but Glenn was not sure about what proportion of white dwarfs did so. He said no white dwarf has cooled enough to stop emitting light. Glenn had another resolved image showing the star Altair (171 light years distant). It revealed an oblong shape caused by the star's rotation, and the disk showed a range of blues.

Glenn said there appear to be no green stars, even though some stars radiate more in the green than at other wavelengths. He said our eyes blend all the wavelengths to produce the colors we see, and green does not stand out. Glenn said if you have the opportunity to see a "green flash" you will know the Sun emits that color. He said he once saw a green flash in the mountains in Arizona.

Glenn's image of Betelgeuse resolved the star's disk and showed a bulge, indicating uneven fusion. He also showed an image of Eta Carinae, estimated to go supernova in about 10,000 years. He said Betelgeuse had about a million years to go. Glenn said he also had done a talk on "How to Blow up a Star" recently. He mentioned two supernovas were seen 30 years apart in the 1500s, and both were visible in the daytime. We talked about the supernova in the Large Magellanic Cloud seen in 1987. Bart Billard recalled (from the book *Shadow of a Star*) that detectors on Earth picked up some neutrinos from the 1987 supernova.

June 2018—ZWO ASI Camera Introduction and DeepSkyStacker Software Demonstration for Deep Sky Astrophotography

Scott Busby's program covered several astrophotography topics. He provided an introduction to a couple of cameras he had brought in to show. He also showed how to use the stacking programs AutoStakkert and DeepSkyStacker. He mentioned a final step he does at home is to process the final image with Photoshop but said he would not be able to cover that step.

ZWO ASI120MM Monochrome 1.2 Mega Pixel Astronomy Camera - ASI120MM

The first camera Scott showed was the ZWO ASI 120 monochrome camera. He showed it came with the cables needed and a nosepiece for installing it on a telescope such as a 1.25-inch eyepiece. He said he also had a color version of the camera, which took the video of Mars that Scott had playing on the screen. Scott said the camera came with SharpCap 3.0 software for capturing the video. He preferred using SharpCap because of its support of proprietary camera features. He did not trust other programs that might rely on ASCOM drivers that might result in some quirks in camera operation.

Scott said he used AutoStakkert for planetary images and would demonstrate with the Mars video. The other stacking program, DeepSkyStacker, was what he used for deep-sky images. Both are available as free downloads. He started AutoStakkert and opened the Mars video, then showed settings he used. He chose "Planet" and "Dynamic Background," which he says he always uses, and set it to use the 75 percent best quality frames. After clicking "Analyze," he chose TIF for the output and checked "Normalize Stack," "Sharpened," and "RGB Align." Scott said RGB Align was not really needed for color video. He then chose stack points and their size. Clicking in the image of Mars placed dots with squares around them that the program would use in lining up features in the stacked image. Scott showed the different sized squares that could be chosen and said he found 48 was a good size to pick lots of features to align. The largest size would cover the whole planet, while the size he chose allowed him to cover the image with a couple dozen or more somewhat overlapping squares. There was a feature called "Drizzle," which he said he keeps turned off. When the stacking was complete, Scott saved the result as a TIF file on the desktop.

The next step was to adjust the image with RegiStax 5.1. Scott first made some display adjustments, mainly reducing the gamma some to make the features show better. Then he showed how he used the wavelets tools to make the image sharper. It involved some experimenting with the settings of how strongly they acted and which ones worked best for the features in the image. When the image was sharpened to his satisfaction, Scott made a little more adjustment of the gamma. He pointed out a pair of bright spots he said were the start of dust storms. Myron Wasiuta said he and Jerry Hubbell had made an image 3 days later that showed the storm had clearly spread. When asked about dust storms, Myron said there are dust seasons on Mars, and the current opposition is occurring in one of the dust seasons. Glenn Faini asked what wavelets were. Scott said he could not explain them, but just played with them until he got the results he wanted. Jerry Hubbell said they are like spatial frequencies.

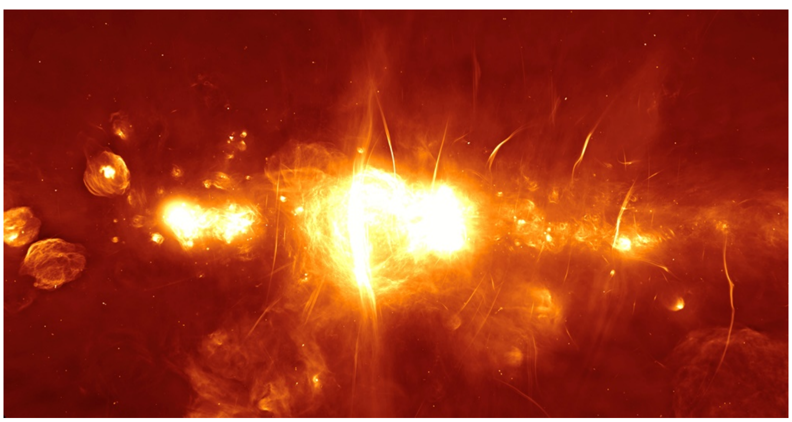
Scott also said he preferred to try for a more “natural” look. He was willing to risk not getting all the detail as long as the result looked natural. Scott said that although opposition was still about a month away, this was the best apparent size Mars has shown in several years. Myron said Mars was already 18 arc seconds and would reach 24 arc seconds in July. Scott explained that he used AutoStakkert for the stacking because it avoids some quirks he has seen in RegiStax. Robert Gupton thought problems with stacking large videos in RegiStax might have to do with a CPU setting. Glenn Faini described using another program to select the best quality frames in the video and save the resulting smaller file without the poorer frames for stacking in RegiStax. Scott ended the discussion of planetary imaging with a comparison of the Mars image before and after the RegiStax processing.

Scott showed his ZWO ASI 1600 camera that he used for deep-sky astrophotography. He had a Canon EOS lens attached and was thus able to demonstrate how to capture video. He said he used “Mono 8” format for easier conversion to JPEG. He preferred a monochrome camera for the detail. To get color, he had to use color filters on the filter wheel he got with the camera, and he takes fewer color images as a result.

Scott opened DeepSkyStacker and used it to open FITS images of NGC 891. He said the first step was to sort through the images for any bad ones to throw out. For example, tracking might have been poor during one exposure, the mount might have been bumped, or maybe an airplane flew through during another. Once the bad images were deselected, Scott started the stacking, and there was time for some discussion while the program worked. Glenn Faini asked whether 60 frames per second was better than 30 for planetary imaging. Scott said he was not able to get such frame rates with his camera. Jerry said faster exposure was better for capturing moments of good seeing. Robert asked whether the deep-sky camera had cooling. Scott showed that it did but mentioned that the power supply’s cable is very short and required an extension cord that could cause problems around the mount.

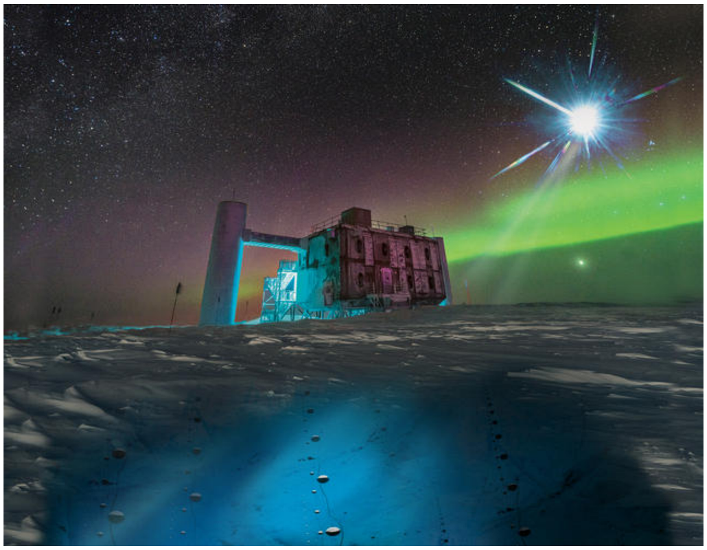
When the stacking was complete, Scott demonstrated some adjustments to bring out details of the galaxy. He also showed a few other images he had previously stacked. One of them was M51, and he varied the adjustments on the image to show how he tried to get details of the smaller interacting galaxy’s tidally dispersed bands of stars without making the result look unnatural to him.

July 2018—Astronomy in the News



MeerKAT photo of the Sagittarius A* region of the Milky Way

Those in attendance discussed “Astronomy in the News.” Glenn Holliday started off with two good news/bad news items. His good news item was a detailed image made with the MeerKAT radio telescope array of the Sagittarius A* region that includes the supermassive black hole at the center of the Milky Way. The MeerKAT array is a precursor to the Square Kilometer Array telescope. Another effort is underway to combine radio telescopes planet-wide for even higher resolution. Glenn said we could expect a lot of papers from these data. His bad news item was another delay of the launch date of the James Webb Space Telescope (JWST). Glenn showed a chart plotting updated launch date projections versus the date when the change in the projection was made. Below it was a straight line matching the date on the vertical axis to that on the horizontal axis. The projected launch dates also appeared to form a straight line suggesting further updates would eventually have the two lines cross in 2026. Glenn noted that the JWST was designed for launch on a European Space Agency (ESA) Arianne 5 rocket, which is going to be phased out as ESA moves to the Arianne 6. There’s a danger the JWST would not have a launch vehicle available if it is delayed too much.



IceCUBE. Courtesy South Pole Neutrino Laboratory

Bart Billard talked about detection of a high-energy neutrino by IceCube, a cubic kilometer of Antarctic ice equipped with an array of 5,160 light detectors. The 290-trillion-electron-volt (TeV) neutrino was detected last September 22. An automated update system established the previous year sent out a notice to astronomers with details of the path within a minute of the event. It resulted in observations at multiple wavelengths that found a likely source, a blazar designated TXS 0506+056. For example, the FERMI satellite showed the blazar was located within 0.1 degrees of the position found by IceCube and was showing an increase in gamma ray emissions at the time. A search of past neutrino detections at IceCube revealed a period of 150 days when about 13 more neutrinos than normal were detected from that source. Bart showed a *Science Magazine* news item with a schematic drawing of how the neutrino was traced backward by the detectors that tracked the shower of charged particles created by the collision of the neutrino with a nucleus in the ice. Dots represented the arrangement of the detectors in the ice, with color and size coding indicating the timing and amount of light detected, respectively. The earliest detections were in blue on one side of the array, and the latest were in yellow on the other side. All were centered along a red line drawn to represent the neutrino path. This observation provided evidence that quasars thought to be active supermassive black holes with jets are sources of cosmic rays. Blazars are quasars with a jet pointing at Earth. The advantage of detecting the neutrinos was the ability to pinpoint their source because neutrinos are not deflected by matter or magnetic fields the way charged particle cosmic rays are.

Scott Lansdale showed a “baby” exoplanet image obtained by the Spectro-Polarimetric High-contrast Exoplanet Research (SPHERE) instrument on the Very Large Telescope in Chile. He mentioned SPHERE recently obtained a sharper image of Neptune than Hubble could do. Scott also talked about a visit to Palomar that he was able to make while in California for work. He arrived at a time he thought would be early for a scheduled tour and found out all the tour tickets were taken 15 minutes earlier. However, as he started on a self-guided tour, he met a girl who had extra tickets she could not use, and he was able to take the tour after all. Scott Busby described the book, *A Perfect Machine: Building the Palomar Telescope*, by Ronald Florence, which he had read and reviewed for the April *StarGazer*.

Don Clark said he had seen a story on black hole formation by giant stars in the early universe. Linda Billard talked about a recent article on the discovery of twelve new moons of Jupiter, bringing the total to 79 known satellites of the planet. All but one of the outer 10 has retrograde orbits (opposite to Jupiter’s rotation).

Glenn brought up a study that suggested 80 to 90 percent of asteroids fell into eight classes by chemical composition. It suggested they might all trace back to eight protoplanets that broke up. Scott Lansdale showed a photo of the Green Bank Radio Telescope and described how visitors could get a tour that took them (when the reflector was leveled) up one of the support booms to the location of the feed horn. Glenn said he saw a story that ESA and the Chinese Space Agency announced a plan for cooperation on going to explore the Moon. Scott said he always dreamed of having a big telescope on the Moon. Glenn agreed and said he had read about having a crater on the far side filled with mercury to make a large mirror. Scott Busby recounted doing planetary imaging in recent months, starting with Jupiter, then Saturn, and lately Mars. He said one of his Saturn images was his best ever and even showed the Encke Gap. On the other hand, Mars now has a global dust storm going on. Linda said she saw an item indicating some recent Curiosity data suggests the storm may have diminished lately, and she was doing a newsletter article about it. Scott agreed he may have seen a little detail coming out again.

Image of the Quarter