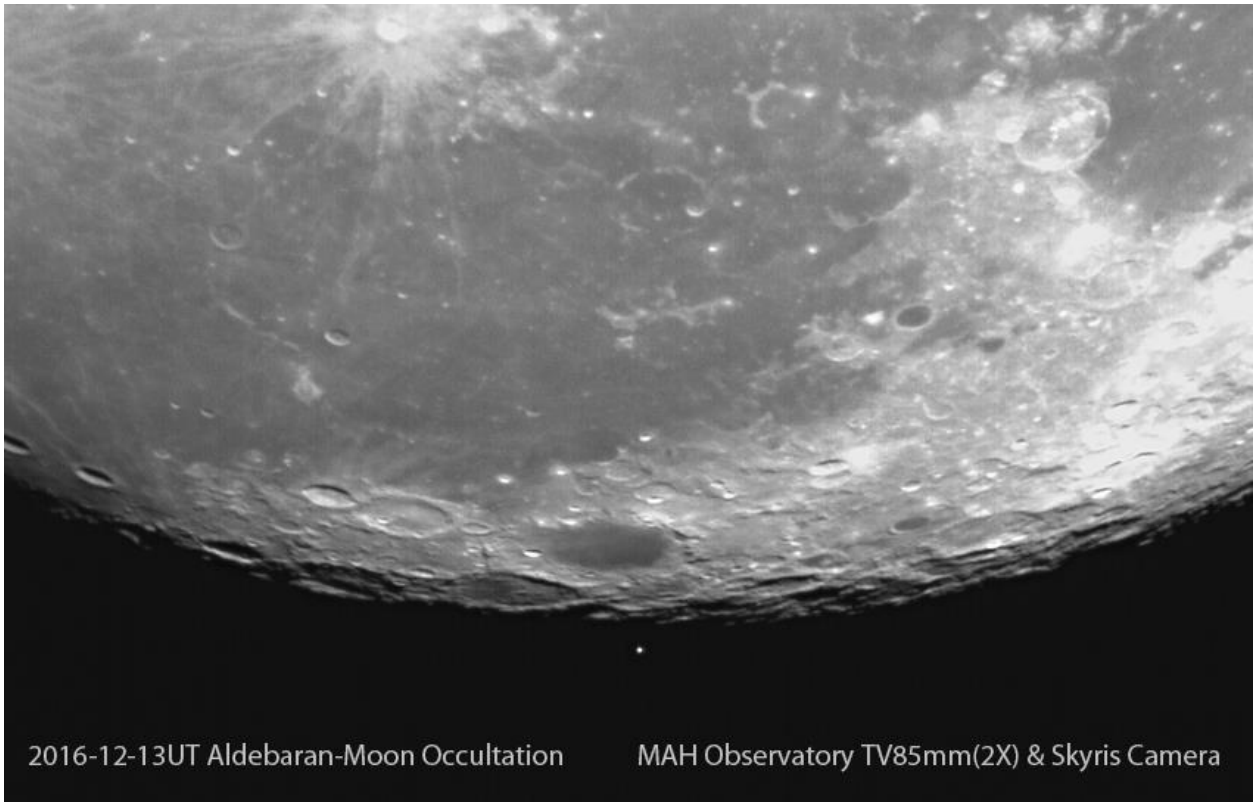
SkyWAAtch



Aldebaran Slips Behind the Moon

Courtesy of Rick Bria is this image of Aldebaran just prior to its occultation by the Moon. As Rick explains: The Moon moves relative to the stars as it orbits the Earth and sometimes it covers a bright star. This is known as an occultation. On December 13, 2016 the Moon covered the star Aldebaran. Aldebaran can be seen below center in the attached picture just seconds before it was covered.

Events like this were once used to measure the Moon's distance and position. That task has since been replaced by scientists shooting laser pulses at prisms placed on the Moon by astronauts. The laser pulse round trip is accurately timed and the Earth-Moon distance measured to a fraction of an inch.

In This Issue . . .

Events for February

WAA February Lecture

"What's New on Mars?"
Friday February 3rd, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

February is traditionally Mars month at WAA. Br. Robert Novak, Chairman of Physics at Iona College (and WAA member) will discuss the latest information on the Martian atmosphere. Br. Novak is a member of NASA's Astrobiology team, headquartered at the Goddard Space Flight Center in Maryland. He is one of the foremost experts on methane on Mars, and is the author or coauthor of over 35 papers. In 2015, his group published an important paper in Science that presented strong evidence for the existence of an ancient ocean that once covered as much as 20% of the Martian surface. In January Br. Novak spent several nights at the summit of Mauna Kea gathering new spectroscopic data with NASA's 3-meter Infrared Telescope Facility. Directions and Map.

Upcoming Lectures

Pace University, Pleasantville, NY

On March 3rd, our presenter will be Mr. Alan Witzgall. His talk is tentatively titled "Going to Mars or Bust."

Starway to Heaven

Ward Pound Ridge Reservation,
Cross River, NY

There will be no Starway to Heaven observing date for February. Monthly observing sessions will recommence on March 18th.

New Members. . .

Matthew Dugan - White Plains
Al Collins - Stamford
Scott Meyer - Mount Kisco
Jinny Gerstle - West Harrison
Constance Outlaw - Tarrytown
Robert M. Hales - Montrose

Renewing Members. . .

J Carlton Gebauer - Granite Springs
Harry S. Butcher, Jr. - Mahopac
James Steck - Mahopac
Warren Lindholm - Cortlandt Manor
Jonathan Gold - Ossining
Alex Edwards - Mahwah
Michael Rinaldi - Scarsdale
Bob Quigley - Eastchester
David Butler -Mohegan Lake
Frank Clemens - Larchmont
Robert Rehrey - Yonkers
Tom & Lisa Cohn - Bedford Corners

Join WAA at NEAF, April 8-9th Rockland Community College, Suffern, NY

WAA will have a booth at the Northeast Astronomy Forum, to be held at Rockland Community College on Saturday, April 8th and Sunday, April 9th. This is the nation's premier astronomy show, with a vast diversity of exhibitors, vendors, equipment, lectures by leading astronomy figures and, weather permitting, the famous Solar Star Party.

We need volunteers to staff our booth. It's an opportunity to meet and chat with fellow club members and other astronomy enthusiasts, and to help recruit new members to the club. It also is a place where you can store your swag while attending lectures or other events. Last year 20 club members participated, we recruited new members and we made many new friends. Put NEAF in your calendar now.

Wanted Assistant Editor

The WAA newsletter (the *SkyWaatch*) is seeking an Assistant Editor. If you can help, please let us know. Your participation in editing, compositing and proofreading tasks or submitting articles or images, will be much appreciated. Email Tom at waa-newsletter@westchestersastronomers.org

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.

Westchester Amateur Astronomers

ALMANAC
For February 2017 by Bob Kelly

Feb 4 Feb 11 Feb 18 Feb 26

The Moon spends a few hours as a shady character on the 10th; Venus reaches for a conjunction with Mars but fails while providing pretty photo ops. Saturn tips its hat to us this year and its moons and Jupiter's dance around the giant planets.

The Moon tiptoes around the edge of the Earth's shadow on the evening of the 10th. It never gets fully into the umbra, the darkest part of our shadow. The grayish coating should be maximally visible over ¾ of an hour centered about 7:44pm. It should be a lovely sight, especially in binoculars.

An annular solar eclipse, a 'ring of fire' not-quite-total-eclipse occurs on the 26th, but not for us! It'll be seen from some parts of South America, South Africa and the Southern Atlantic.

Venus reaches for Mars, but Mars plays hard-to-get and succeeds. They hang out in our evening twilight skies for much of the month. Venus slims to a crescent, growing larger in extent as it comes within half-a-million miles from Earth. Venus is much closer than all the other planets, with Mercury more than twice as far and Mars four times further. Mars continues to dim as we pull away, but at magnitude +1.2, it's still brighter than all but 17 stars.

Venus starts on its trip toward the solar glare, but moving higher on the celestral sphere, it's actually easier to catch than late last year. It's highest in the daytime sky in the late afternoon; block out the Sun and see if you can find it 40 degrees out from the Sun.

Jupiter is up in the southern sky by morning, with good views of the Great Red Spot on the 5th, 10th, 17th and 22nd. Look for moons appearing and disappearing on many mornings. Jupiter and Spica pair up nicely; just close enough to capture the attention of the casual observer.

Saturn greets early risers low in the southeast and south. Saturn appears tilted 26.6 degrees toward Earth, so its north pole is tipped toward us. This year is the maximum tilt of the rings for this half of Saturn's 29 ½-year trip around the Sun.

Saturn's fainter moons are overwhelmed by the brilliance of the rings, but Titan, at magnitude +8.4 is easier to find than the others. My favorite moon, Iapetus, moves from just above Saturn to arrive 9 arc seconds out to the west of Saturn on the 19th, traveling ahead of it as they move through the sky. Iapetus also brightens from magnitude +11 to 10 as its bright side slowly turns in our direction.

Mercury pops back up – into the morning sky. Try to find it very low in the southeast. It flashes across the SOHO LASCO C3 frame of view starting about the 25th.

Minor planet Vesta dims to magnitude +7.0 in February, as it drifts through Gemini.

Good photo ops this month are when the Moon skims the southern part of the Hyades' "V" on the 5th, poses with Jupiter and Spica on the 15th, and is nearby Venus and Mars at the start and end of February.

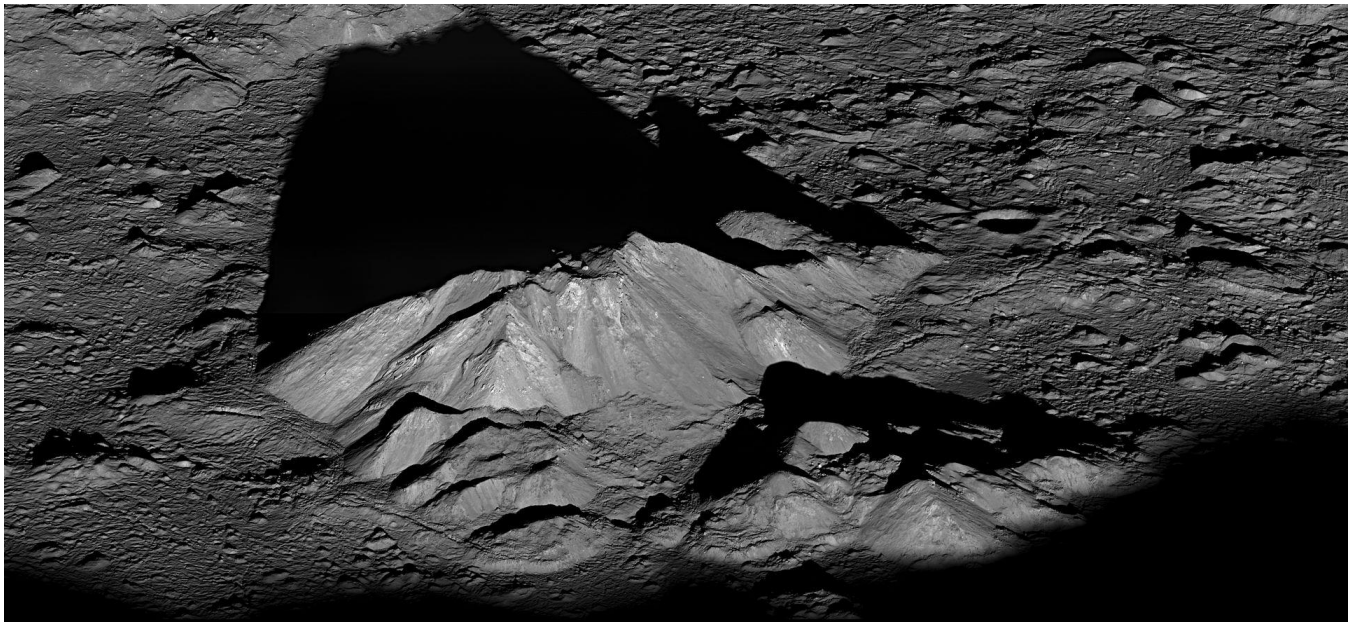
The International Space Station is visible in the evening sky through the 19th and back to the morning sky at the end of the month. Check out Tinagong 2, presently uninhabited, which gets as bright as 1st magnitude at times. The previous home for Chinese takonauts, Tinagong 1, is slowly losing altitude and getting easier to observe as it gets closer to Earth. Try in the evening at the start of the month and the morning near the end. Will the Air Force ever call OTV-4 home? Launched May 20, 2015, it shines at magnitudes 1 to 3 during the second and third weeks in the morning sky.

Ever see Leo leap up and dive down in the same night? Connect the dots and see the rise after sunset and the dive just before morning twilight. Meanwhile, lay out in your chaise lounge (do they even call them that anymore?), look overhead and let the three Messier objects in Auriga float through the field of your binoculars.

Uranus and Neptune get their curtain call from the evening sky this month. Use Mars to find Uranus around the 26th. Use your telescope to compare the colors and size of these two tiny-looking objects. Good luck finding Neptune in the Sun's glare! It might just be visible in SOHO C3 starting in late February.

We Visit the Lunar Reconnaissance Orbiter Camera Operations Center

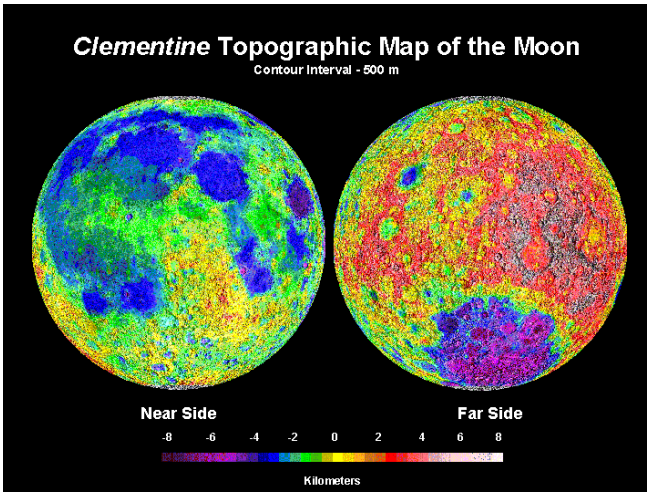
Larry Faltz



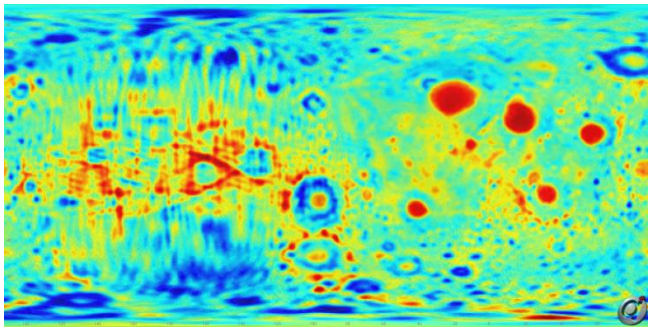
The central peak of Copernicus as imaged by LROC

It's hard to believe that it's been more than half a century since the first successful mission to the Moon, the Soviet Luna 2, which impacted on the eastern side of the Mare Imbrium on September 14, 1959. Our exploratory horizons have gone far beyond our nearest cosmic neighbor as we've sent probes to all the planets, to comets and into interstellar space. Nevertheless, the manned Apollo missions still thrill us as humanity's greatest feat of exploration. Their scientific results are no less impressive: they led to new information about the origin of our companion and the early solar system (see the February 2014 SkyWAAtch). We've retrieved 2,415 samples of lunar rocks weighing 380.96 kilograms (839.87 lb) from the six Apollo flights. Three unmanned Soviet Luna spacecraft returned with 326 grams (11.5 oz) of lunar rocks. In addition, since 1980 over 120 lunar meteorites representing about 60 different meteorite impact events (none witnessed) have been collected on Earth, with a total mass of over 48 kilograms (106 lb). From these specimens, as well as other scientific data, a coherent and scientifically consistent history of lunar formation and geologic evolution has been constructed.

For a time after Apollo, the moon receded from our consciousness and scientific goals even more dramatically than it physically recedes from Earth, by 3.8 centimeters [1.5 inches] per year. There were 13 attempts at lunar missions in the late 1950's, of which 2 were successful (both Soviet). In the 1960's, there were 59, of which 18 US [4 manned, 2 of which were orbiters and two landers] and 9 Soviet succeeded, and in the 1970's there were 17 missions with the moon as the primary target, of which 13 were successful (4 US [all manned landers], 8 Soviet). But in the 1980's neither the US nor the Soviet Union sent a spacecraft to our satellite. On January 24, 1990, lunar exploration recommenced when Japan launched the Hiten probe, which was intended as a flyby but was placed into lunar orbit after its Hagormo probe failed to communicate after separating from Hiten.



The US returned to the moon in 1994 with the Clementine mission, which mapped the moon from orbit. Among many scientific results, Clementine made a detailed photographic atlas of the moon with a resolution of 7-20 meters and a topographic radar map with vertical resolution of 40 meters, and horizontal resolution of about 100 meters. It also quantified the surface composition of a number of atomic species. Four years later, Lunar Prospector made a lunar gravity map, detected water ice deep in craters on the lunar South Pole and made more measurements of the surface composition using several spectrometers.



Gravity map of the moon from Lunar Prospector. Far side is on the left, near side on the right.

The next US lunar mission was THEMIS in 2007. This group of 5 satellites was designed for observations of Earth's magnetosphere, but two were later shifted into lunar orbit where they observed the moon's interaction with the sun. These probes are apparently still operating, long beyond their design expectations, although the most recent scientific information available on-line is from 2013.

In 2007 and 2008, China, Japan and India all launched successful lunar spacecraft. On June 18, 2009, NASA launched the Lunar Reconnaissance Orbiter (LRO), an analogue to the Mars Reconnaissance Orbiter (MRO) that was launched in 2005 and is still operating around the red planet. LRO is in an eccentric polar orbit ranging from 20 to 165 kilometers above the lunar surface. LRO was designed with ambitious objectives:

1. Find potential landing sites for future missions.
2. Map regions of permanent shadow or illumination that may be good sites for permanent bases because they could contain water ice.
3. Create high-resolution maps of polar massifs with permanent or near-permanent illumination for future exploration.
4. Observe regions from multiple angles to derive high-resolution topography to help understand lunar geology.
5. Improve maps of mineralogical components of the lunar crust, to find materials that may be sources of oxygen and possibly fuels for future missions.
6. Create a global morphology base map for geologic research.
7. Characterize the regolith to understand the conditions around future landing sites.
8. Determine impact hazards by comparing new images with Apollo 15-17 images and assessing the rate of meteorite impacts to gauge risk for future long-stay missions.

Now, 7 years after it began operation, it has completed many of the initial objectives and has been placed into an "extended mission phase" with four main goals:

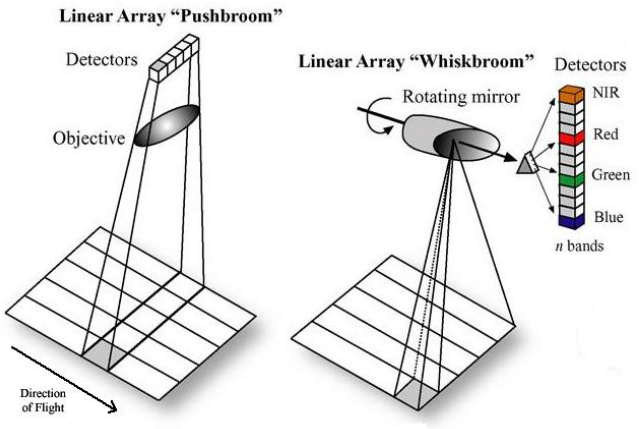
1. Determine the bombardment history of the moon for 10,000 identified sites, and measure mineralogical composition in these areas.
2. Investigate the evolution of the lunar crust.
3. Investigate the evolution of the lunar regolith.
4. Investigate volatiles in the polar regions.

To achieve these goals, the LRO has a suite of seven scientific instruments. They deliver approximately 155 gigabytes of data per day. Perhaps the most important is the Lunar Reconnaissance Orbiter Camera (LROC), which was designed and is operated by Arizona State University. The principal investigator is Mark Robinson, a professor at the School of Earth and Space Exploration.

There are three LROC cameras. Two are high-resolution narrow angle black-and-white cameras with a resolution of just 0.5 meters per pixel. They can be used to make stereographic images. Each is a 195 mm f/3.59 Ritchey-Chretien telescope with an effective focal length of 700 mm. The third camera is a wide-angle imager that can be operated in color, black-and-white or in the ultraviolet. It has a resolution of 75 meters per pixel with a field of view of 60 kilometers. It uses a lens with a focal length of just 6 mm (4.7 mm in the UV). The detectors for all of the cameras are Kodak chips. An on-board compression system prepares the data for transmission to Earth.

Imagine uses the "push-broom" concept. In this mode, a linear array of detector pixels acquires images across the width of the field as the spacecraft sweeps over the target surface, the way a push broom clears a path on your basement floor. All of the pixels of the linear array are acquired at the same time. The Mars HiRISE camera on MRO, operated by the University of Arizona, is also a "push broom" instrument. A more com-

plex system called "whisk broom" is used in many high-resolution Earth satellites. It emulates the motions of a whisk broom, which the user sweeps from side to side across the floor. This system has a rotating mirror that gathers the information pixel by pixel. It can be sharper, but because it is mechanical it is more subject to failure and so is not used for planetary survey missions.



Push-broom vs. whisk broom imaging

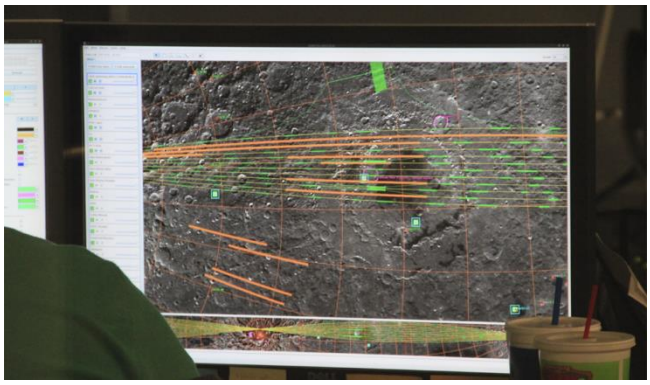
Elyse and I found ourselves at the LROC Operations Center by accident and serendipity. When we visited the ASU Meteorite Museum in April 2016, we ran into Meg Hufford, the Senior Coordinator of the School of Earth and Space Exploration. She suggested that after our visit to the museum, we should have lunch at *Engrained*, an excellent healthy-eating restaurant in the student union building (who would have thought there's healthy food on a college campus?) and then go next door to the Interdisciplinary A building, headquarters of the LROC.

Unlike the modern and dramatic ISTB4 that houses the School of Earth and Space Exploration (see the January 2017 Sky*WAA*tch), Interdisciplinary A is a two-story 1960's-era brick building. It's probably seen many academic units come and go. Right now it houses, in addition to LROC, the Graduate Education Office, the Hispanic Research Center, the Study Abroad Office and something called the Office of Student-Centric Initiatives (what do they do at a university that isn't student-centric?). Walking into the ground floor, it's clear that lunar science is the dominant and proudest occupant. The walls were lined with posters about the moon and lunar exploration, as well as images from LROC, Clementine and Lunar Prospector.

As we were reading and discussing the rich information in the displays, staff member Aaron Boyd came over and asked if he could help us. We explained our interest in astronomy and our connection to WAA and ASU (my cousin, who was with us, is a retired professor of linguistics). Boyd is a research analyst on the LROC team. He told us a little about the project, and then disappeared for a moment into a locked room, shortly emerging with gift, an envelope containing large format (37"x25") LROC Lunar Charts, 3rd edition, published by NASA in February 2016. These beautiful maps are scaled at 1:10,000,000 resolution. One is photographic and the other topographic. I couldn't find a reference to them on the NASA or LROC web site, but I did find a terrific interactive photographic map on the LROC web site.

The LROC Science Operations Center (LF)

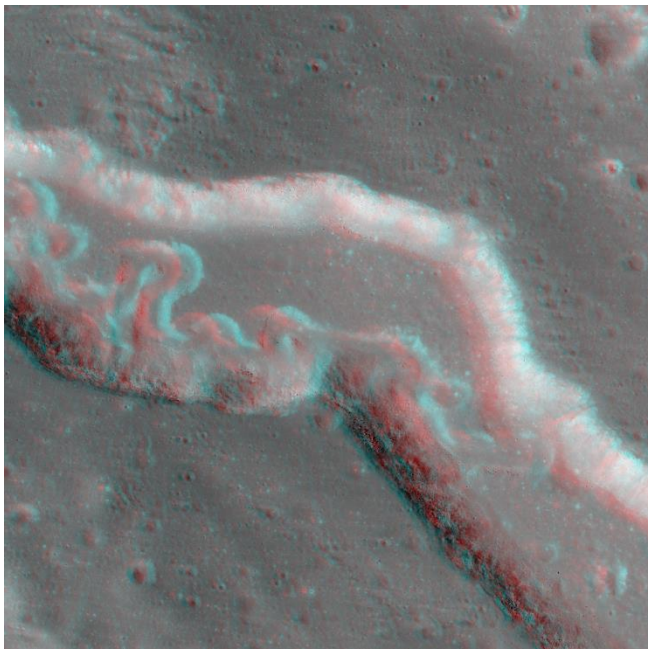
At the far end of the first floor corridor was the glassed-in LROC Science Operations Center, a very large room that had educational displays, a few small telescopes and several rocket models as well as lots of computer equipment and monitors. An actual moon rock, about 3 inches high, was housed in a cylindrical glass display case, with a large sign saying "CAUTION! Do not touch glass. ALARMED!"



LROC image trajectory plots (LF)

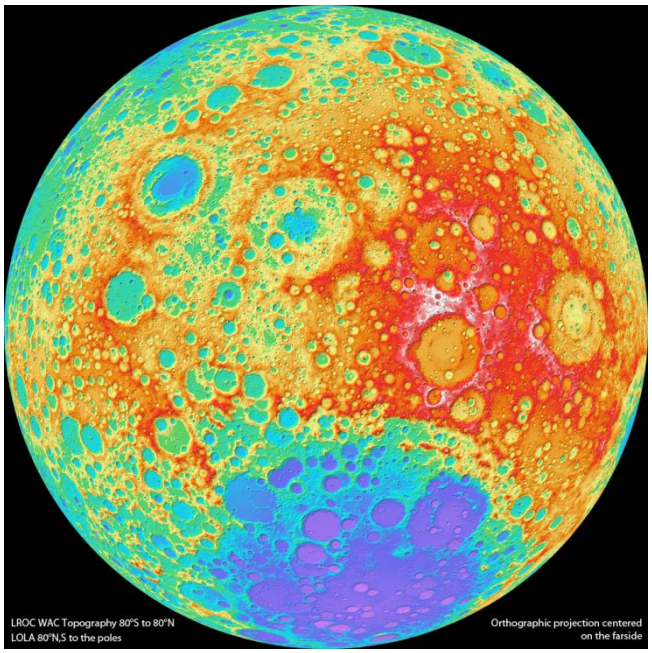
One corner of the room was dedicated to camera control and data acquisition. Three members of the LROC team were downloading images of the moon and plotting trajectories, as could be seen on one of the monitors. Sadly, the glass window prevented us from overhearing their discussion, so we couldn't get any insight into how decisions are made at the technical level (assuming we could understand their jargon, probably unlikely).

There are thousands of LROC images and interactive tools available on the LROC web site. Some of the images show lunar topography from an oblique angle, rather than merely overhead. The image of Copernicus at the top of this article is a typically impressive example. Among the many spectacular images that have come down from LROC are stereographic images that are rendered on the LROC web site as analgyphs. Similar to the dramatic 3-D renderings of the topology of Mars by HiRISE, these views of lunar topography are fascinating and instructive.



Anaglyph of Vallis Schroeteri. Use your 3-D glasses.

We watched for a while as different images came down and the three scientists continued their intense (but silent to us) discussion. After a while we went next door to the Moeur Building, a 1939 adobe edifice that houses ASU's Mars Spaceflight Facility. ASU scientists have designed and managed instruments on Mars orbiters and rovers to explore the geology and mineralogy of the red planet. These instruments include the Thermal Emission Imaging System (THEMIS) on NASA's Mars Odyssey and two Mini-Thermal Emission Spectrometers (Mini-TES) on the Mars Exploration Rovers, Spirit and Opportunity. As mentioned in last month's article, ASU is responsible for the new Mastcam on Mars 2020, the successor to Mars Science Laboratory (Curiosity).



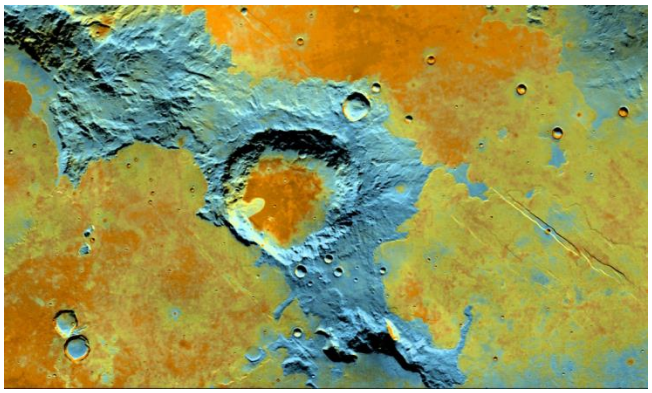
LROC topographic image of the lunar far side.

In addition, the ASU Mars Education Program, an outreach program for students and teachers is housed in Moeur. The entrance lobby was crowded with displays, including a full-size model of Mars Opportunity, posters about the various instruments, a collection of geology specimens with scientific analyses of their composition, and windows looking into several laboratories.

Lobby displays at the Mars Space Flight Facility, ASU (LF)

The Mars Odyssey spacecraft has been operating in a circular orbit since 2001. The THEMIS instrument provides imaging at infrared wavelengths and has

helped define the planet's surface composition and geologic dynamics.



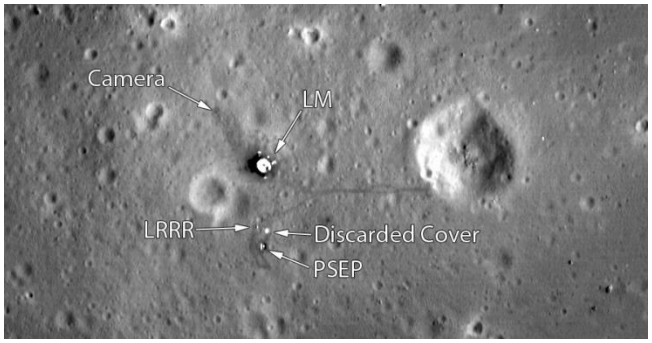
A THEMIS image of an area in Terra Sirenum on Mars

In addition to many educational posters lining the halls at LROC, we saw an announcement for an exhibition of LROC images at the National Air and Space Museum in Washington DC. As luck would have it we were scheduled to be in the nation's capital for a few days at the annual meeting of my professional society, the American College of Physicians, just two weeks after our Arizona trip. We resolved to make time to see the exhibit, and we were able to get there on May 4th. The show ran from February 16 to December 31, 2016 (WAA members received an announcement about it on June 12th).

On any visit to the Air and Space Museum you encounter vast crowds of excited visitors flocking to the most famous displays (the Wright Brothers' airplane, the Spirit of St. Louis, the Apollo 11 capsule) or eagerly awaiting an IMAX movie or planetarium show. There are many noisy and marginally restrained student groups from all over the country, but what student wouldn't be enthused in that marvelous space? Fortunately the LROC show "A New Moon Rises" was tucked away at the eastern end of the museum's second floor in the "Flight and the Arts" gallery. We shared the suite of spacious rooms with just a few other interested people, and were able to contemplate the material without any distractions.

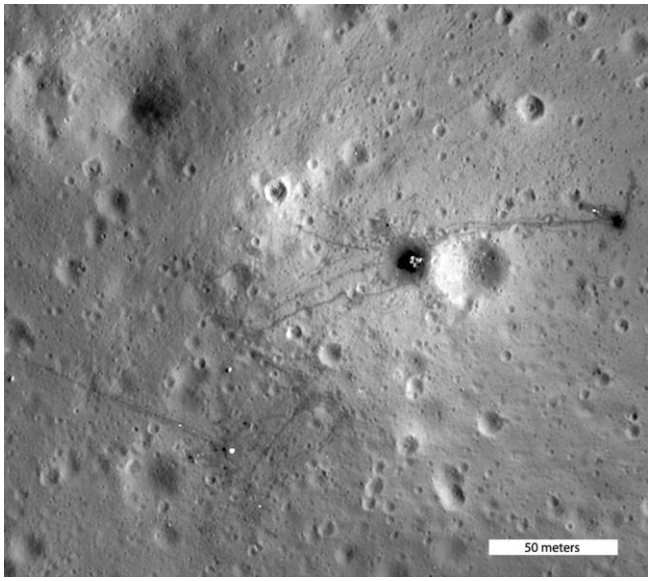
As good as the LROC images are on line, when professionally printed in large format they are simply spectacular. The rich black-and-white patina of the prints made me think "Ansel Adams in outer space." There were some wonderful topographic images in color that used LROC data along with laser data from another instrument aboard the LRO spacecraft. An engineering version of the camera itself, along with a detector and some electronics, was also on display.

Images from the LROC exhibition at the National Air and Space Museum in Washington, DC (LF)



Annotated LROC image of the Apollo 11 landing site

Among the many fantastic images captured by LROC, available on-line and displayed at "A New Moon Rises," are the landing sites of all of the Apollo missions, as well as other American, Russian and Chinese lunar landers and impactors. Astronaut tracks from all the Apollo missions and lunar rover tracks from Apollo 15, 16 and 17 are quite visible on these images. Equipment left on the surface is clearly evident. Many of the small research devices left on the moon and even some of the flags left by the astronauts are discernible.



Apollo 16 landing site, showing the lunar module, astronaut and lunar rover tracks and, on the right, the parked rover

I suspect that in addition to the 8 reasons enunciated as primary scientific goals of the LRO there was a ninth: get direct visual proof that the moon landings occurred in order to rebut the moronic but never-ceasing arguments by the surprisingly large lunatic fringe of moon-landing deniers who still infect popular culture.

Between 6 and 20% of Americans, and 28% of Russians, believe the moon landings were faked. The arguments advanced in support of these fantastic claims are easily rebutted (there are no stars in the sky on photographs taken by the astronauts because they would be not visible at the speed and f/ stop needed to get a good image of the bright surface, etc.) but the nature of belief and a desire to have an exceptional hold on the truth can motivate zealots, especially those who revel in their ignorance of science or look for confirmations of their own powerlessness by imagining grand conspiracies. This hasn't been helped by silly TV shows that suggest the hoax was real (for example, Fox's 2001 show *Conspiracy Theory: Did We Land on the Moon?*). The conviction that the moon landings were faked even makes it into the movie *Interstellar*, where it was clearly intended as a way to ridicule the bankrupt educational culture encountered by the protagonists Cooper and his daughter Murphy, but I wonder how many naïve moviegoers might have been misled by this reference. I recently read Michael Shermer's 1997 book *Why People Believe Weird Things* (another score from Pasadena's wonderful Book Alley, this copy even signed by the author). Shermer may be familiar to you as a columnist for *Scientific American*. He is the founding publisher of *Skeptic* magazine and a knowledgeable and patient supporter of rational thinking and science.

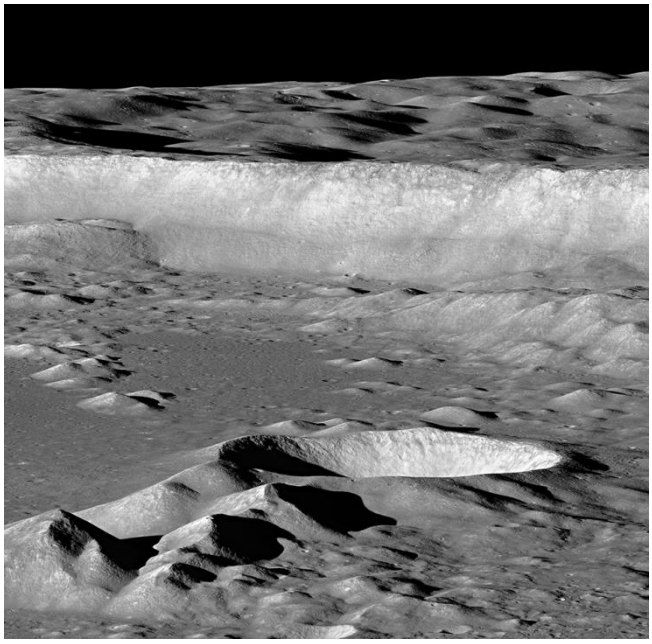
Shermer doesn't specifically discuss Apollo conspiracy theories, focusing mainly on alien abductions, creationism and Holocaust denial. There are many reasons why people believe unbelievable things, with various effects on our society. Alien abductions are a form of hysteria but they are essentially harmless to others. Creationism clearly emanates from the Christian fundamentalist view that the Bible must be literally true. It has a negative impact on the educational system when its proponents succeed in altering school science curricula by claiming equivalence between creationism (or its offspring "intelligent design") and Darwinian evolution. In Pennsylvania, Judge John E. Jones III struck down such an attempt, ruling against the creationists in *Kitzmiller, et al. v. Dover Area School District*. He described intelligent design as "breathtaking inanity," and surely it is. Holocaust denial has a more pernicious source, that of anti-Semitism. Shermer gives a list of 25 fallacies that cause people to believe weird things, ranging from various misunderstandings of the scientific method to "the need for certainty." He quotes "Hume's maxim", from Chapter 10, "On Miracles," in *An Enquiry Concerning Human Understanding* by the great Scottish philosopher David Hume (1711-1776):

> The plain consequence is (and it is a general maxim worthy of our attention), 'that no testimony is sufficient to establish a miracle, unless the testimony be of such a kind, that its falsehood would be more miraculous, than the fact, which it endeavors to establish…. When anyone tells me, that he saw a dead man restored to life, I immediately consider with myself, whether it be more probable, that this person should either deceive or be deceived, or that the fact, which he relates, should really have happened. I weigh the one miracle against the other; and according to the superiority, which I discover, I pronounce my decision, and always reject the greater miracle. If the falsehood of his testimony would be more miraculous, than the event which he relates; then, and not till then, can he pretend to command my belief or opinion."

In other words, which is more miraculous: that we actually went to the moon, or that there was a conspiracy involving 400,000 people who worked on the Apollo program to build phony spacecraft and launch them live on television, create lots of doctored photographs, construct false personal testimony, rework terrestrial rocks to have chemical and isotope compositions never previously found on Earth, leave "clues" that only the believers can explain (if the conspirators can do all that, why didn't they remember to paint stars on the moon sets?) and keep all the people presumably involved in this plot from coming forward?

There are still quite a few individuals who believe the Earth is flat. Rapper B.o.B., with 2 million Twitter followers, challenged Neil deGrasse Tyson on this point earlier this year, tweeting "No matter how high in elevation you are... the horizon is always eye level." But the "horizon" is always what's at eye level, bozo. TV and social media "personality" Tila Tequila tweeted "If Earth was a spinning globe then how come the North Pole is ALWAYS seen in the same spot?" I'm too flabbergasted even to comment on that one. There's been about 2,500 years of solid, consistent evidence that the Earth is round, and yet the Flat Earth Society's Facebook page has, as of this writing, 23,832 "likes." On their message board, the thread "TOP 10 REASONS 'Why We Know the Earth is Round' Debunked" (referring to an on-line video that explains the irrefutable evidence for a spherical Earth) has already seen 146,655 views. The reasons are hilariously stupid. The explanation for "stars change," meaning the variation in the appearance of the celestial sphere with latitude, the seasons and even throughout the night, is that "[it's] another assumption. This time, [the author of the video is] assuming that Flat Earth geography is just a Mercator map. It's not. The Earth is a disk centered around the North Pole, which would provide the same effect." But of course, if you think about it for 1 second, you correctly conclude it wouldn't be the same effect. I'm sure the writer flunked geometry. A flat Earth's sky wouldn't change as you moved north or south, nor would it alter with the seasons. And here is the totally wacky explanation for photographic evidence of a round Earth: "Most photographic evidence actually demonstrates what we would expect to see on a disk shaped, flat Earth: a circle with little to no apparent curvature. Add in camera distortion, and that's our explanation for low Earth photos. [F in geometry again!] As for photos like the famous Blue Marble, that the space agencies of the World are involved in a conspiracy is depressingly obvious if you look at the evidence." Of course, there is no such evidence, but even more obvious is the answer to the question of what possible reason countries could have to engage in a conspiracy to hide the "truth" of a flat Earth? Just apply Hume's Maxim to the problem.

I feel sad for all these conspiracy-loving fantasists. They miss out on the great and beautiful canvas of reality. They fail to see the marvelous interaction between all of the parts of science, tied together by the miracle of mathematics, which allows us to understand nature's laws and use them for the advance of humanity. That the world is knowable and we can all talk about it in the same way is a gift that we've received from all of our scientific forbearers. What an utter waste of one's brain not to believe it. ■



Floor and eastern wall Antoniadi crater (LROC)

Comet Campaign: Amateurs Wanted

Marcus Woo

In a cosmic coincidence, three comets will soon be approaching Earth—and astronomers want you to help study them. This global campaign, which will begin at the end of January when the first comet is bright enough, will enlist amateur astronomers to help researchers continuously monitor how the comets change over time and, ultimately, learn what these ancient ice chunks reveal about the origins of the solar system.

Over the last few years, spacecraft like NASA's Deep Impact/EPOXI or ESA's Rosetta (of which NASA played a part) discovered that comets are more dynamic than anyone realized. The missions found that dust and gas burst from a comet's nucleus every few days or weeks—fleeting phenomena that would have gone unnoticed if it weren't for the constant and nearby observations. But space missions are expensive, so for three upcoming cometary visits, researchers are instead recruiting the combined efforts of telescopes from around the world.

"This is a way that we hope can get the same sorts of observations: by harnessing the power of the masses from various amateurs," says Matthew Knight, an astronomer at the University of Maryland.

By observing the gas and dust in the coma (the comet's atmosphere of gas and dust), and tracking outbursts, amateurs will help professional researchers measure the properties of the comet's nucleus, such as its composition, rotation speed, and how well it holds together.

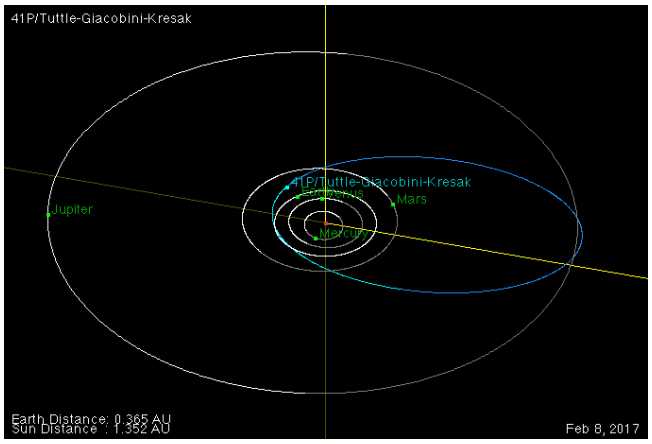
The observations may also help NASA scout out future destinations. The three targets are so-called Jupiter family comets, with relatively short periods just over five years—and orbits that are accessible to spacecraft. "The better understood a comet is," Knight says, "the better NASA can plan for a mission and figure out what the environment is going to be like, and what specifications the spacecraft will need to ensure that it will be successful."

The first comet to arrive is 41P/Tuttle-Giacobini-Kresak, whose prime window runs from the end of January to the end of July. Comet 45P/Honda-Mrkos-Pajdusakova will be most visible between mid-February and mid-March. The third target, comet 46P/Wirtanen won't arrive until 2018.

Still, the opportunity to observe three relatively bright comets within roughly 18 months is rare. "We're talking 20 or more years since we've had anything remotely resembling this," Knight says. "Telescope technology and our knowledge of comets are just totally different now than the last time any of these were good for observing."

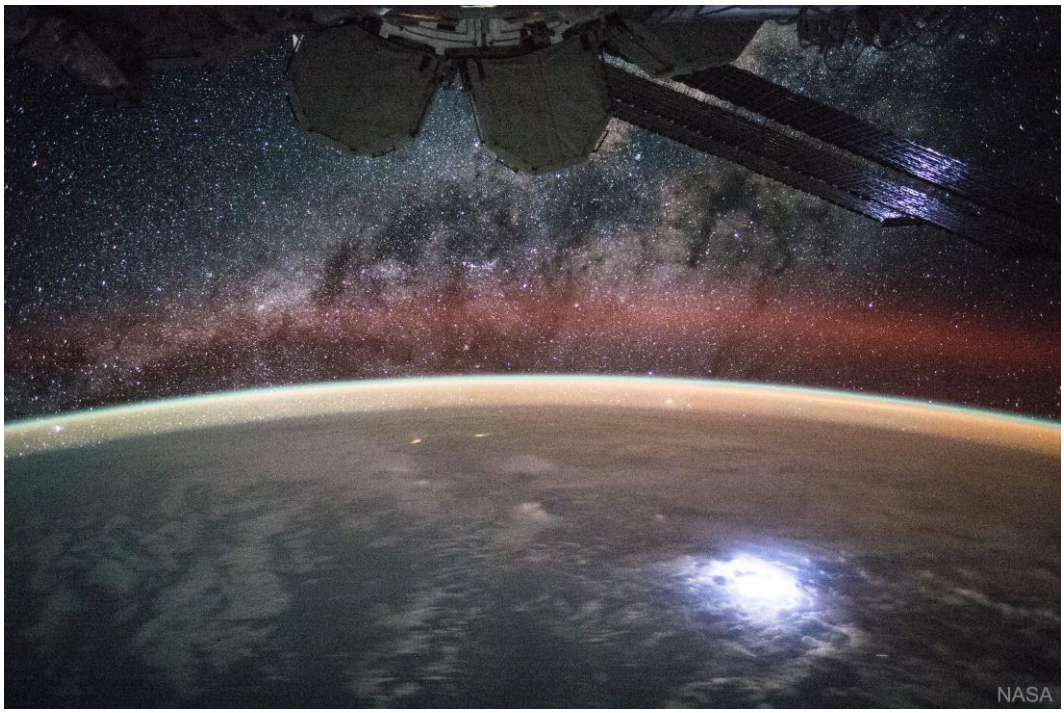
For more information about how to participate in the campaign, visit http://www.psi.edu/41P45P46P.Want to teach kids about the anatomy of a comet? Go to the NASA Space Place and use Comet on a Stick activity! http://spaceplace.nasa.gov/comet-stick/.

This article is provided by NASA Space Place. With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science



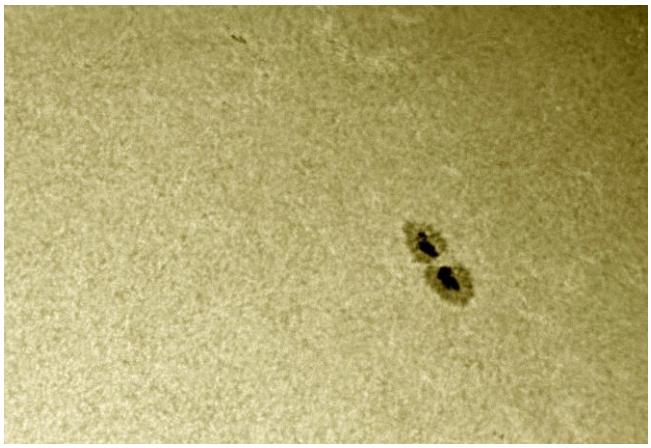
An orbit diagram of comet 41P/Tuttle-Giacobini-Kresak on February 8, 2017—a day that falls during the comet's prime visibility window. The planets orbits are white curves and the comet's orbit is a blue curve. The brighter lines indicate the portion of the orbit that is above the ecliptic plane defined by Earth's orbital plane and the darker portions are below the ecliptic plane. This image was created with the Orbit Viewer applet, provided by the Osamu Ajiki (AstroArts) and modified by Ron Baalke (Solar System Dynamics group, JPL).
http://ssd.jpl.nasa.gov/sbdb.cgi?orb=1;sstr=41P

Astrophotos



If you could circle the Earth aboard the International Space Station, what might you see? Visible at the top, are parts of the ISS solar panels. Just below the station is the band of our Milky Way Galaxy, glowing with the combined light of billions of stars. The band of red light just below the Milky Way is airglow -- Earth's atmosphere excited by the Sun and glowing in specific colors of light. That's our Earth below its air, with the terminator between day and night visible near the horizon. As clouds speckle the planet, illumination from a bright lightning bolt is seen toward the lower right.

Credit: APOD
Image Credit: NASA, JSC, ESRS



John Paladini provided these images of the Moon (left) and Sunspots (right) taken through a 7-inch f/15 Orion maksutov telescope. The solar image utilized a 20A sodium filter