Galactic Observer

John J. McCarthy Observatory

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A chain of large sunspots emerged over the Sun's southeastern limb in late October. From end to end the chain of magnetic islands stretched almost 100,000 miles (150,000 km) with each sunspot being about twice the size of Earth

Image: Bill Cloutier (captured with the McCarthy Observatory's antique refractor)

December Astronomy Calendar and Space Exploration Almanac

★ **Sky at Night** ★

This beautiful collage of the night sky was created by the students in the summer program at the Children's Center in New Milford.

It is an example of the marriage of art and science that is at the heart of the Children's Center's approach to learning that encourages curiosity and expression.

The children made trips to the library to research the sizes and colors of the planets, then, using a variety of techniques created this scene of stars and many planets (Saturn apparently being the most popular).

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McCarthy Observatory
New Milford, CT

“Out the Window on Your Left”

It’s been 52 years since Gene Cernan left the last boot print on the Moon’s surface. As a nation founded on exploration and the conquest of new frontiers, today’s commitment to return to the Moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

For Earth-bound lunar observers, the Sun rises on the Taurus-Littrow valley on the evening of December 5th. A narrow breach in the rim of the Serenitatis Basin, the valley is enclosed on three sides by large, blunt peaks - the South, North, and East Massifs. On December 11, 1972 the valley was the destination of Apollo 17, the final lunar mission of the Apollo program.

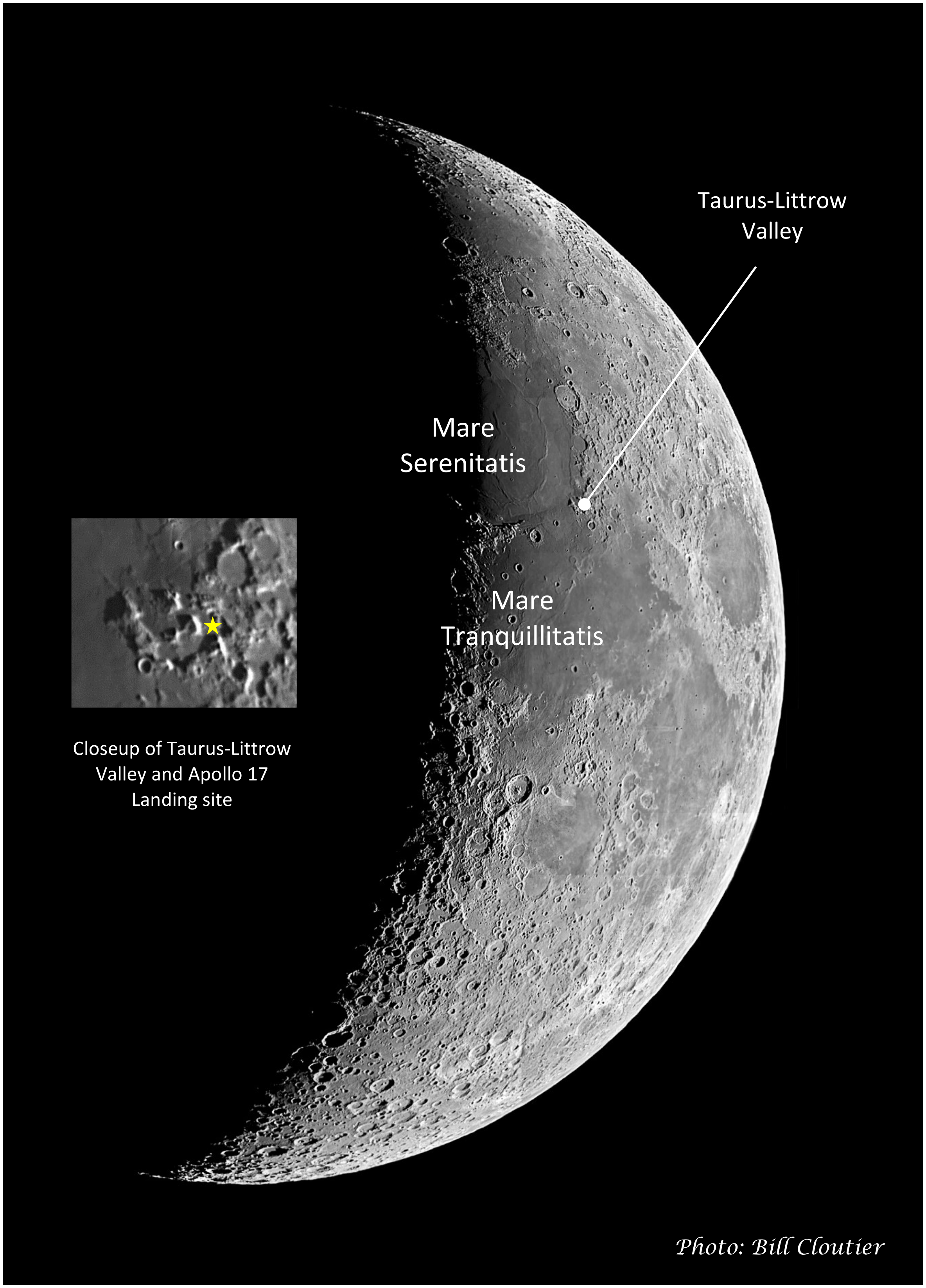
Multiple sites were considered for the last mission, offering diversity of terrains, history and geology. Taurus-Littrow provided the explorers, including astronaut-geologist Harrison Schmitt, an opportunity to visit craters on the valley floor with dark halos. The lunar module set down near one such crater, called “Shorty.”

It was on the rim of Shorty that Schmitt discovered a deposit of “orange soil.” The substance was later determined to be volcanic glass, likely spewed from a volcanic vent or fire fountain. The glass formed 3.64 billion years ago from material that had melted several hundred miles below the surface. The glass erupted onto the surface, was then buried, and later excavated by impacts.

Scientist-astronaut Harrison Schmitt stands next to a huge, split lunar boulder during the third Apollo 17 extravehicular activity at the Taurus-Littrow landing site. The Lunar Roving Vehicle can be seen in the background.
Image Credit: NASA/Eugene Cernan

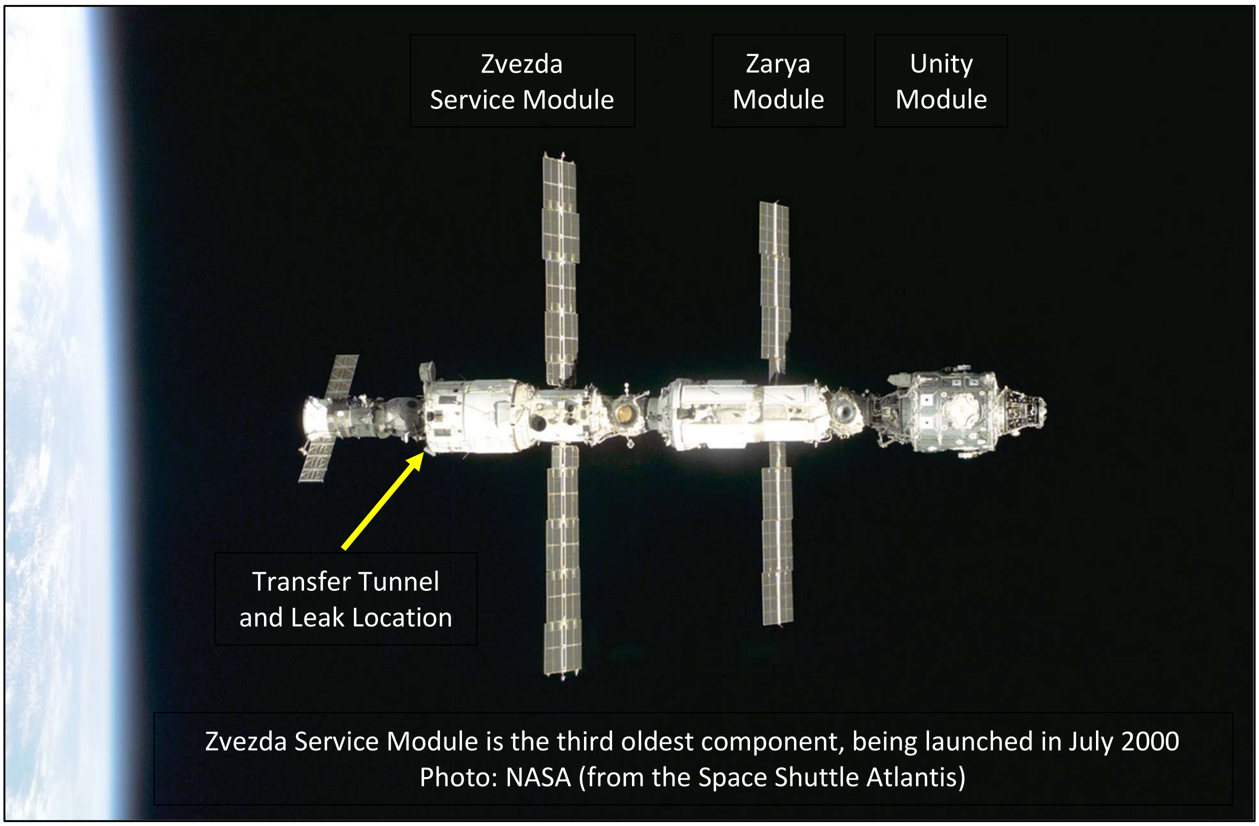
The Apollo 17 mission featured the most extensive lunar exploration of the program with three moonwalks, each lasting more than seven hours. The crew collected the oldest known, unshocked lunar rock (at least 4.2 billion years old) - suggesting that the Moon had, at one time, a magnetic field generated by a dynamo at its core. The astronauts took more than 2,000 photographs and collected about 243 pounds (110 kg) of soil and rock samples at 22 different sites.

Taurus Littrow



A Risky Business

For the astronauts that live and work in space, the findings of the latest audit by the Office of Inspector General (OIG) titled “NASA’s Management of the International Space Station and Efforts to Commercialize Low Earth Orbit” should be troubling, although not completely surprising for a structure that has some components that are more than 25 years old. When the station was first launched in 1998, Russia and the United States were jointly responsible for operations, maintenance and repairs. Since then other international partners have joined (including the Canadian Space Agency, European Space Agency, and Japan Aerospace Exploration Agency), but certain functions, for example attitude control and re-boost propulsion, are reliant on Russian resources. The United States and its other partners have agreed to operate and maintain the station through 2030. At this time, Russia has only agreed to support the station until the expiration of its current 2028 certification date, although negotiations are ongoing for an extension.

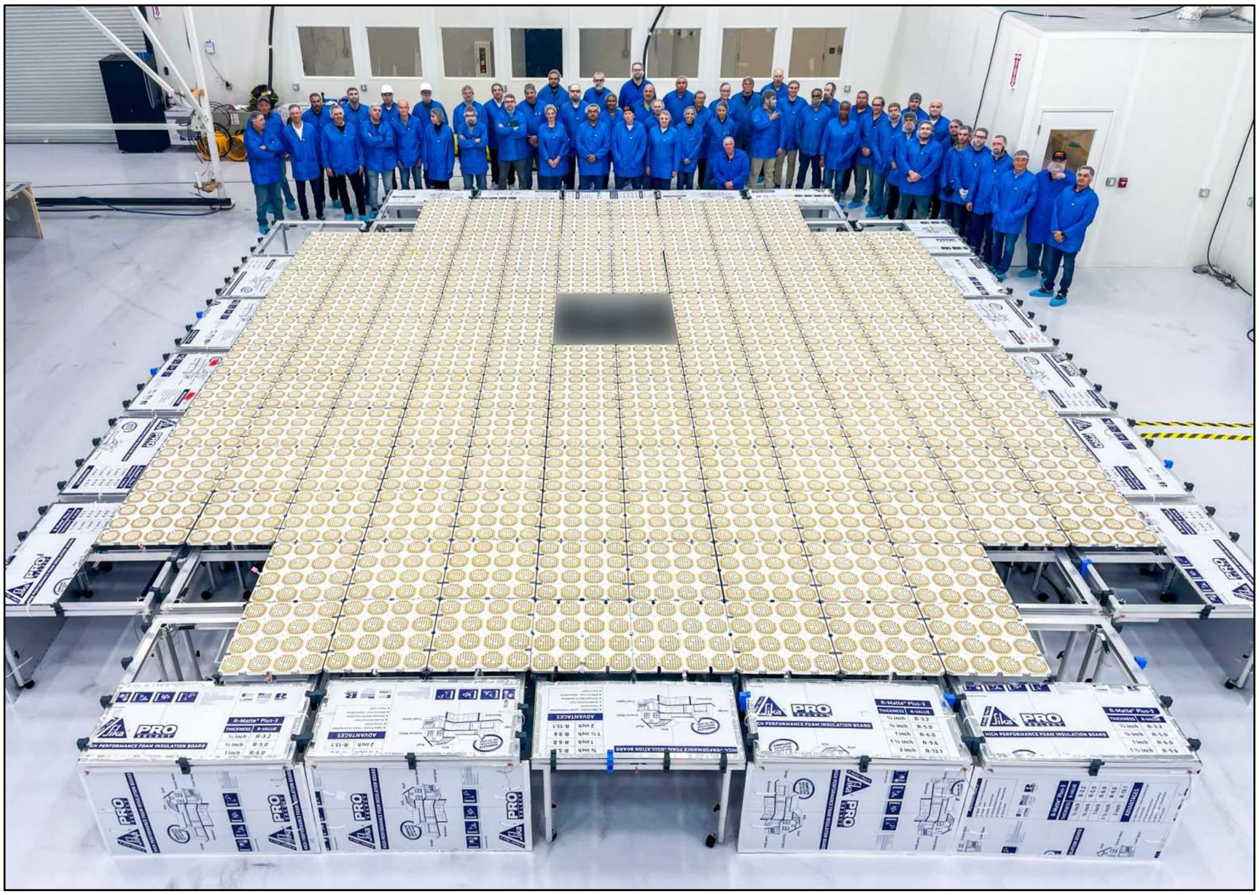


Zvezda Service Module is the third oldest component, being launched in July 2000
Photo: NASA (from the Space Shuttle Atlantis)

The OIG audit identified a number of concerns. The highest risk (scored 5 out of 5) was the leak in the Russian Service Module Transfer Tunnel. Since 2019 when the leak was discovered, the air loss has increased from 1.2 pounds per day to 3.7 despite numerous efforts to locate and seal the source(s). Other concerns raised included deferred maintenance (the audit identified 588 components operating beyond their planned operational lifetime) and delays in a station deorbiting plan.

The OIG was also concerned with the growing threat from orbital debris, damage that has been inflicted on both the station and visiting spacecraft in the past, and the possibility that an impact in the future could necessitate the evacuation of the station. Should such an emergency arise, astronaut safety is also at risk by the lack of redundancy, i.e., the delay in certification of the Boeing Starliner leaves SpaceX’s Crew Dragon as the sole U.S. transportation option.

Filling the Sky with Unwanted Light



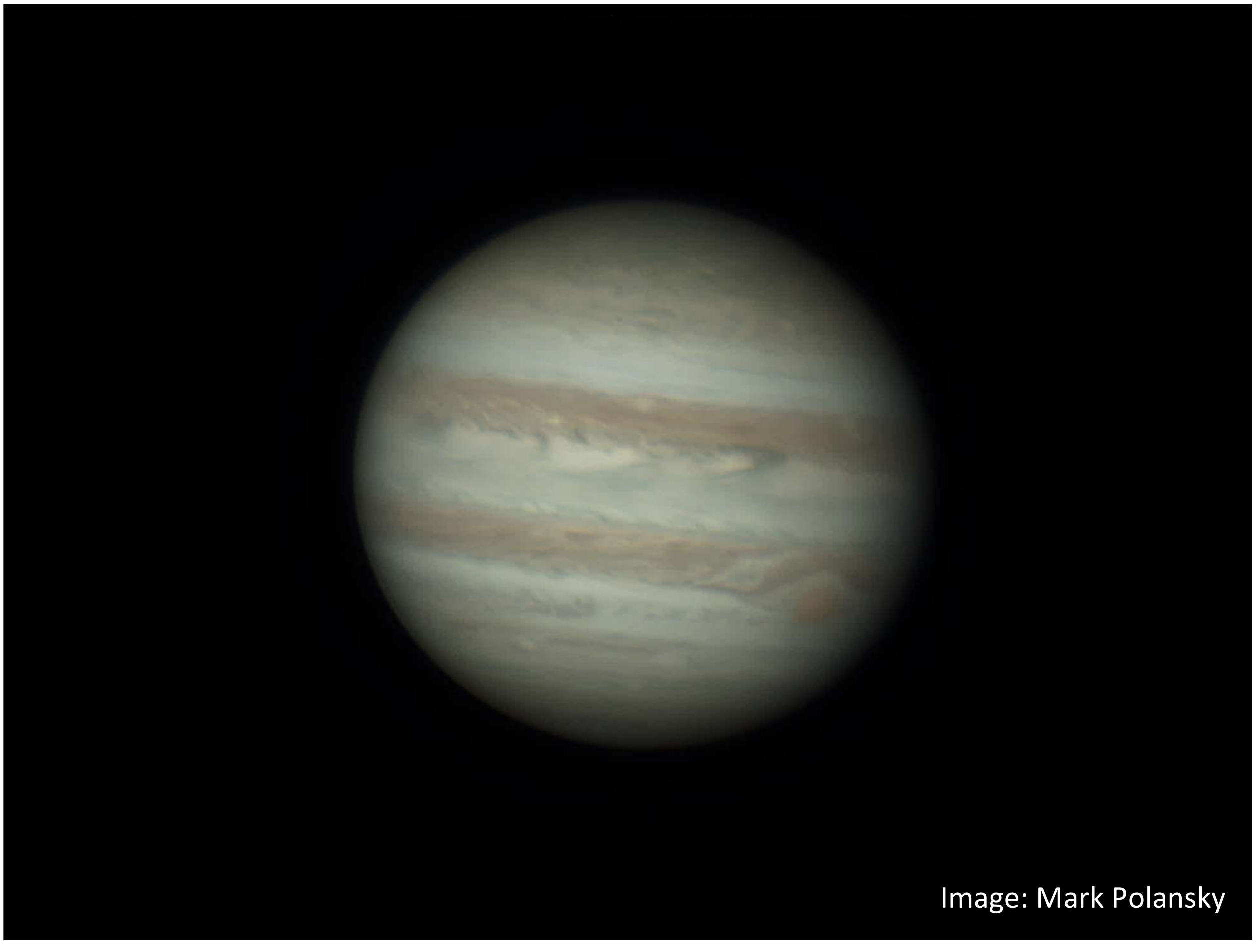
The smaller Block 1 BlueBird satellite
Credit: AST SpaceMobile

While there have been great strides in ground-based astronomy, with grander and more capable Earth-based telescopes under construction, the race to deploy fleets of commercial satellites is even now diminishing the scientific return of these state-of-the-art eyes on the sky. The total number of operating satellites orbiting the Earth as of May 2023 was 7,560. That count has only increased in the past year.

The latest satellite constellations are not only larger, but brighter. SpaceX's Starlink satellite constellation is planned to have up to 42,000 satellites in low-Earth orbit when complete. In response, Chinese companies have started launching their own satellite constellations to compete, including Shanghai Spacecom Satellite Technology’s “Thousand Sails Constellation,” a planned 14,000 mega-constellation and Geespace’s planned 6,000 satellite network. Amazon's Project Kuiper is planning to deploy a constellation of 3,236 satellites while a Texas telecommunications startup AST SpaceMobile just launched its first five massive “BlueBird” communications satellites. Their next-generation satellites (Block 2) will be more than three times the size of the current Block 1 BlueBird satellites and measure 2,400 square feet (223 square meters). For comparison, this is half the size of an NBA basketball court.

The smaller BlueBird satellites are already brighter than most of the stars and planets in the sky. Astronomers now not only have to contend with skies that are growing increasingly brighter from intruding artificial lights, but the swarms of satellites that photobomb their survey work.

Jupiter at Opposition

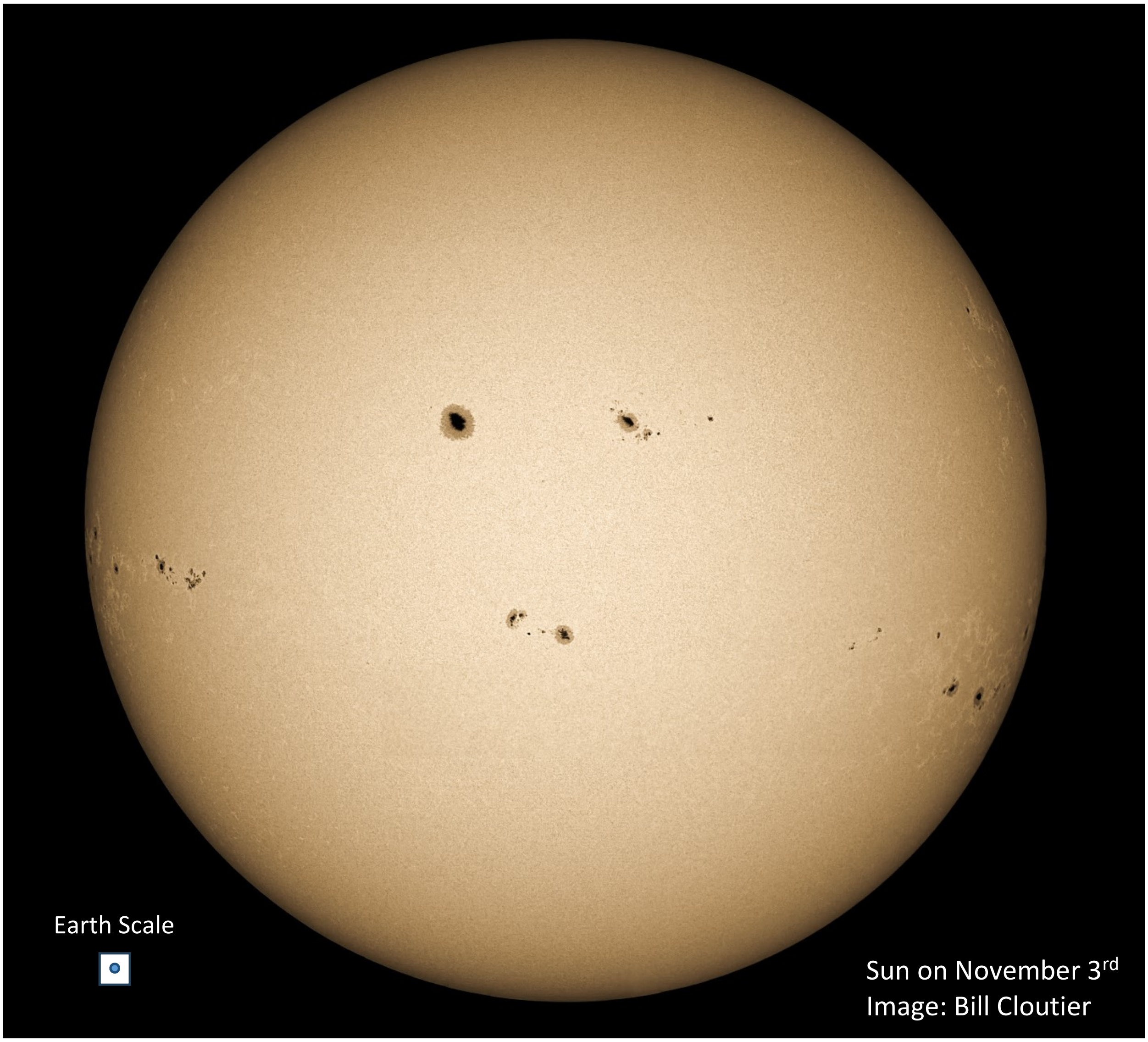


Jupiter, the fifth planet from the Sun and largest in the solar system (more than twice as massive as all the other planets combined) is closest to Earth this year on December 6th, just one day before Opposition. With a diameter of almost 87,000 miles (140,000 km), Jupiter is 11 times wider than Earth (if Jupiter was the size of a basketball, the Earth would be the size of a nickel). At last count, Jupiter has 92 moons, although only the four largest (the Galilean moons) are visible in binoculars or a small telescope. The Galilean moons: Io, Europa, Ganymede, and Callisto, were first observed by the astronomer Galileo Galilei in 1610. Ganymede is the largest moon in the solar system (larger than the planet Mercury), and Io the most volcanically active body. Europa, the target of NASA's Europa Clipper mission, is suspected to harbor a large liquid water ocean beneath its icy crust.

Jupiter makes a complete orbit around the Sun in 12 Earth-years and has the shortest day in the solar system (about 10 hours). It spins nearly upright with its equator tilted with respect to its orbital path around the Sun by just 3 degrees. Comprised primarily of hydrogen and helium, the gas giant is covered by layers of rapidly shifting clouds. The upper layer contains ammonia ice while underlying layers likely include ammonium hydrosulfide crystals, water ice and vapor. Nine spacecraft have visited Jupiter (seven flybys and two orbiters). The latest, NASA's Juno spacecraft, arrived in 2016 and currently orbits the gas giant once every 53 days.

NASA's Europa Clipper and the European Space Agency's Jupiter Icy Moon Explorer (Juice) spacecraft are expected to arrive in the Jovian system in 2030 and 2031, respectively.

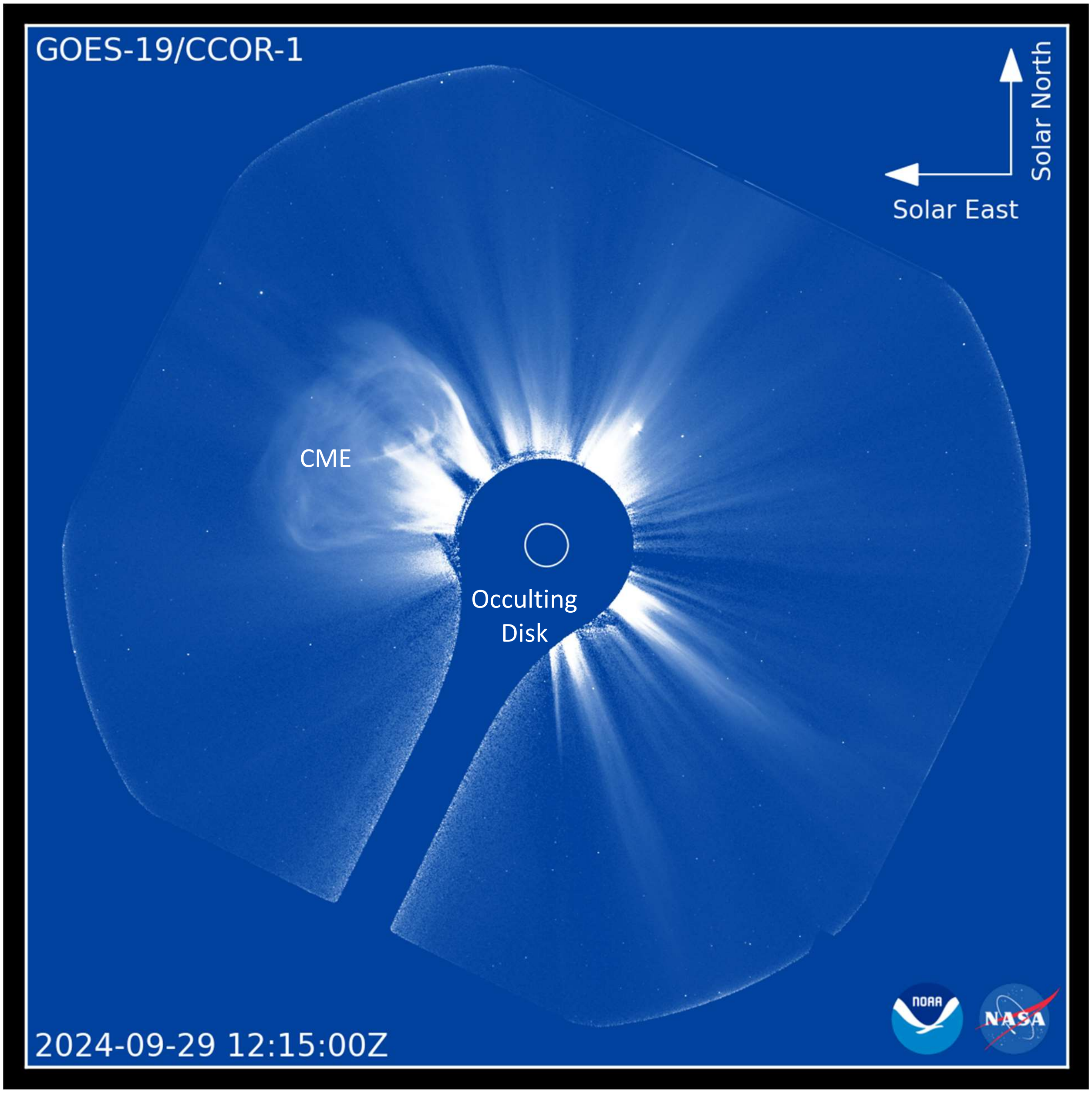
Solar Maximum Arrives (at least for one hemisphere)



On October 22nd representatives from NASA, the National Oceanic and Atmospheric Administration (NOAA), and the international Solar Cycle Prediction Panel announced that the Sun had reached its solar maximum, the peak of the current solar cycle (Cycle 25). Heightened activity, however, could continue well into next year.

The Sun goes through a natural cycle, typically lasting 11 years (although it can be as short as 9 years or as long as 13 years), where solar and magnetic activity transition from low to high and back to low. In periods of high activity the Sun's photosphere is generally speckled with sunspots while the solar disk can be blank around solar minimum. During solar maximum, the Sun's magnetic field changes polarity (the magnetic poles flip). The reversal happens over the duration of a year or two when the polar magnetic fields are weakened and replaced with a new field of the opposite polarity (e.g. going from positive to negative). Activity can vary by hemisphere and the southern hemisphere has been much more active this cycle. Solar physicists are curious whether what they seeing is only a peak for the southern hemisphere and that solar maximum may come later for the northern hemisphere (a delay known as the "Gnevyshev gap").

New Early Warning Tool



In June, NOAA's newest Geostationary Operational Environmental Satellite (GOES-19 was launched into orbit 22,236 miles (35,785 km) above the equator. At this location the satellite is able to continuously monitor the same area of the Earth and track weather conditions, as well as detect and track environmental hazards such as wildfires, smoke, dust storms, volcanic eruptions, turbulence and fog as they develop.

GOES-19 is also the first to be equipped with a Compact Coronagraph (CCOR-1) for solar observations. The coronagraph uses an occulting disk to block out the bright solar disk to observe the Sun's faint atmosphere. CCOR-1 delivers a new image of the corona every 15 minutes. It will be used by NOAA to develop space weather forecasts and monitor Corona Mass Ejections (CMEs) like the one shown in the image above (the billowing cloud of particles at the 10 o'clock position) which can affect communications and electrical transmission systems on Earth.

A Coronagraph for the Roman Space Telescope

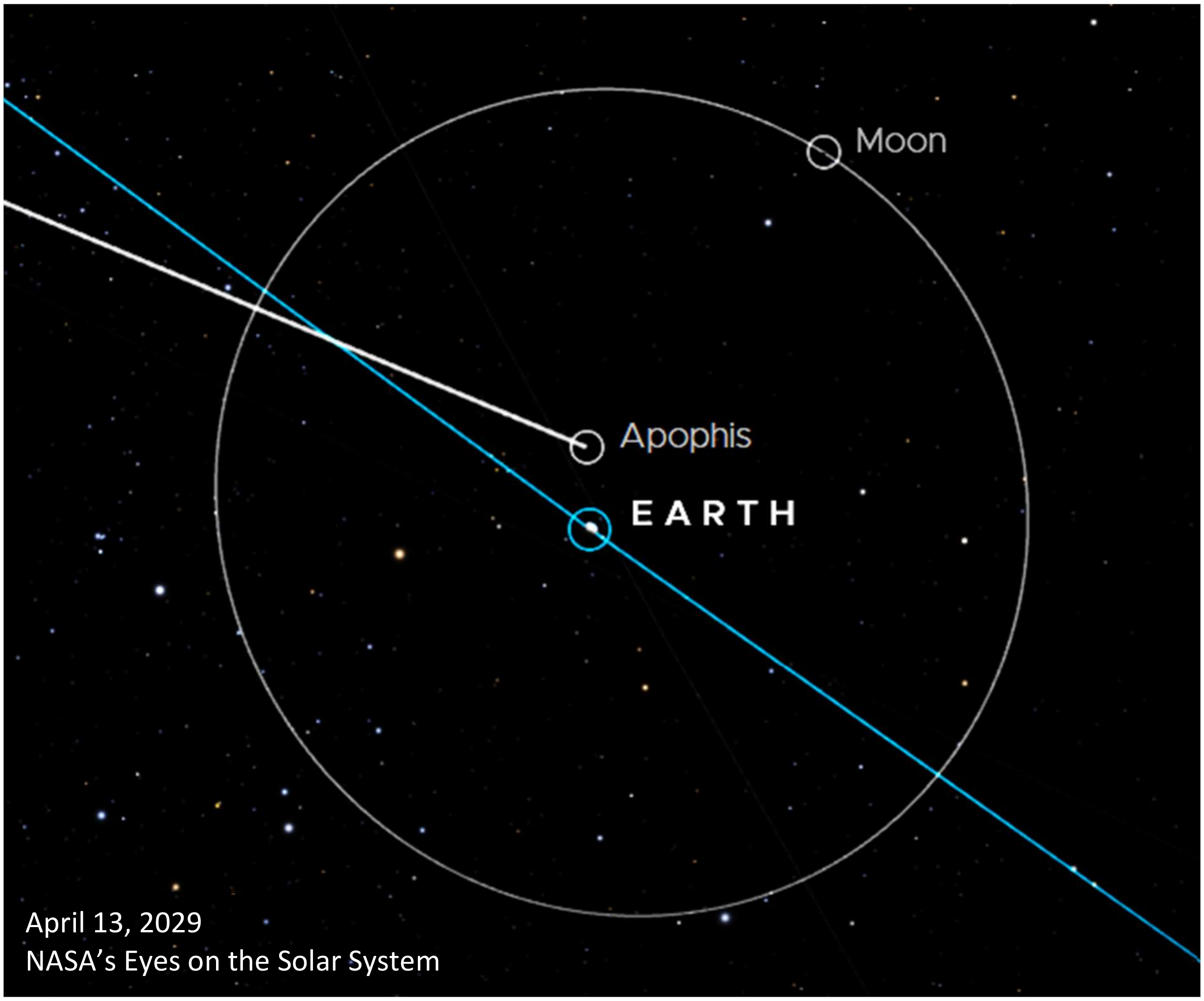
The Roman Coronagraph being installed on the Instrument Carrier at NASA's Goddard Space Flight Center in Greenbelt, Maryland
NASA/Sydney Rohde

NASA's Nancy Grace Roman Space Telescope will use a cutting-edge instrument to directly observe exoplanets (planets around stars other than our Sun). The coronagraph, which uses a collection of masks and active mirrors to block the glare from stars, can reveal planets that are 100 million times fainter than their host stars.

The instrument is a technology demonstration and roughly the size and shape of a baby grand piano (measuring about 5.5 feet or 1.7 meters across). It was developed, built and tested at NASA's Jet Propulsion Laboratory before being shipping to the Goddard Space Flight Center. The coronograph has recently been installed on the telescope's Instrument Carrier, which will be united with the spacecraft at a later date.

The telescope is a NASA flagship astrophysics mission with a field of view at least 100 times larger than the Hubble Space Telescope. It is expected to launch no later than May 2027 and join the James Webb, Gaia and Euclid telescopes at Lagrange Point 2, a stable gravitational point around 1 million miles (1.5 million km) directly behind the Earth in relation to the Sun. The telescope was originally called the Wide Field Infrared Survey Telescope but renamed in May 2020 to honor Nancy Grace Roman, who served as NASA's first chief astronomer from 1961 to 1963. Her vision and advocacy for better observing tools led to the development and launch of the Hubble Space Telescope in 1990.

ESA Proposes to Intercept Apophis

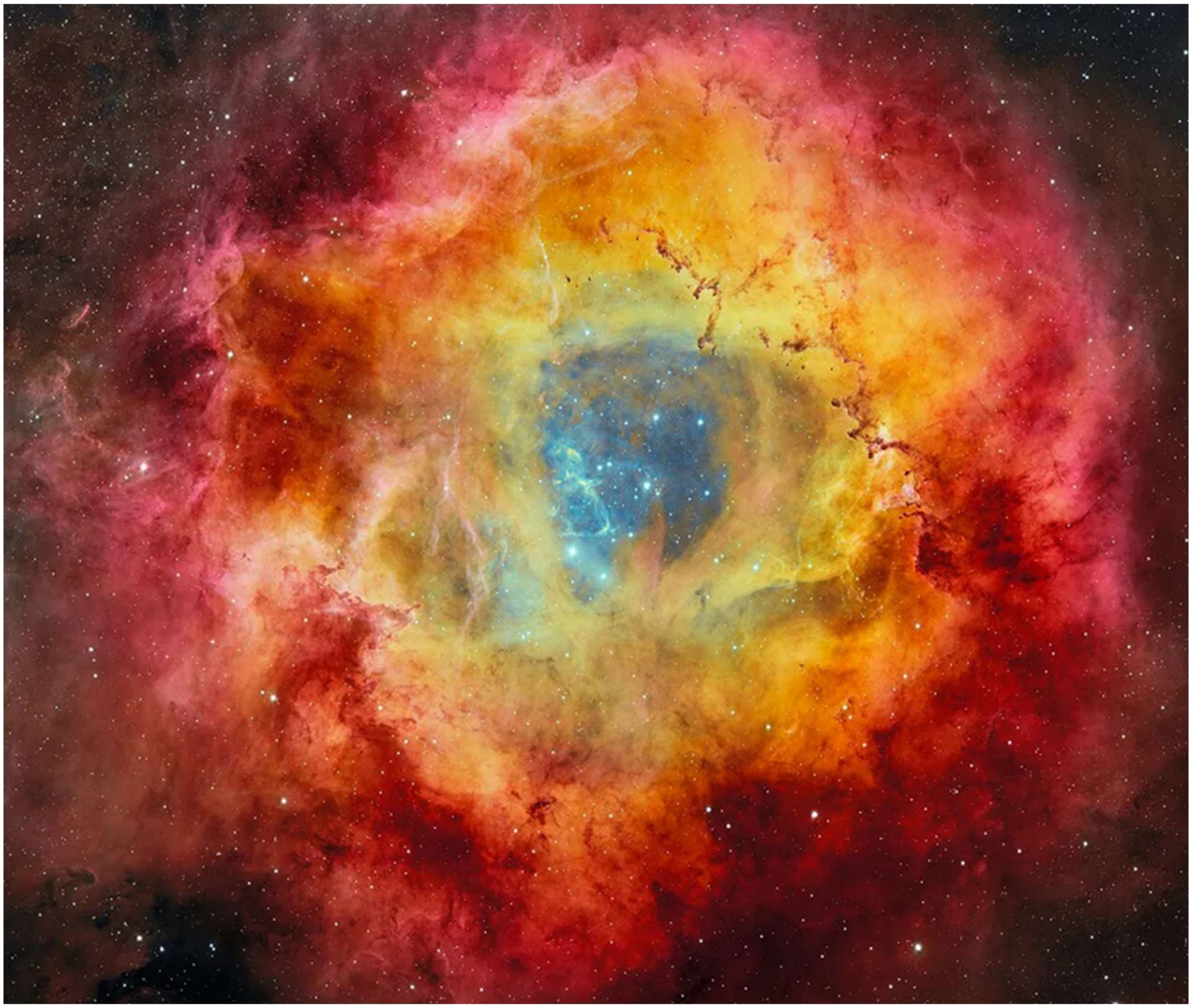


Asteroid 99942 Apophis is a near-Earth object or NEO. Discovered in 2004, the space rock is estimated to be about 1,100 feet (335 meters) across. While there are no impact solutions in the immediate future, Apophis will pass less than 20,000 miles (32,000 kms) from our planet's surface on April 13, 2029. This is closer than the geosynchronous orbit of some artificial satellites (22,236 miles or 35,786 kms).

To take advantage of this exceptional opportunity, NASA has repurposed its OSIRIS-REx spacecraft to rendezvous with Apophis. On its current trajectory, the spacecraft is not able to intercept the asteroid until a month after its closest approach to Earth. The European Space Agency, however, has conceptualized a mission for even greater scientific return.

The Rapid Apophis Mission for Space Safety, or "Ramses," would meet up with the asteroid about two months before close approach. By accompanying the asteroid through its passage between the Earth and Moon, researchers will be able to monitor physical changes in the rocky body and flight path as it passes through Earth's gravity and magnetic field. Much like the recently launched Hera mission to the binary asteroid system Didymos-Dimorphos, Ramses would deploy two CubeSats once at Apophis – one to study the asteroid from a distance and the second to attempt a landing. For the mission to succeed, assuming it is funded, the spacecraft would need to launch in 2028.

Rosetta Nebula Revealed

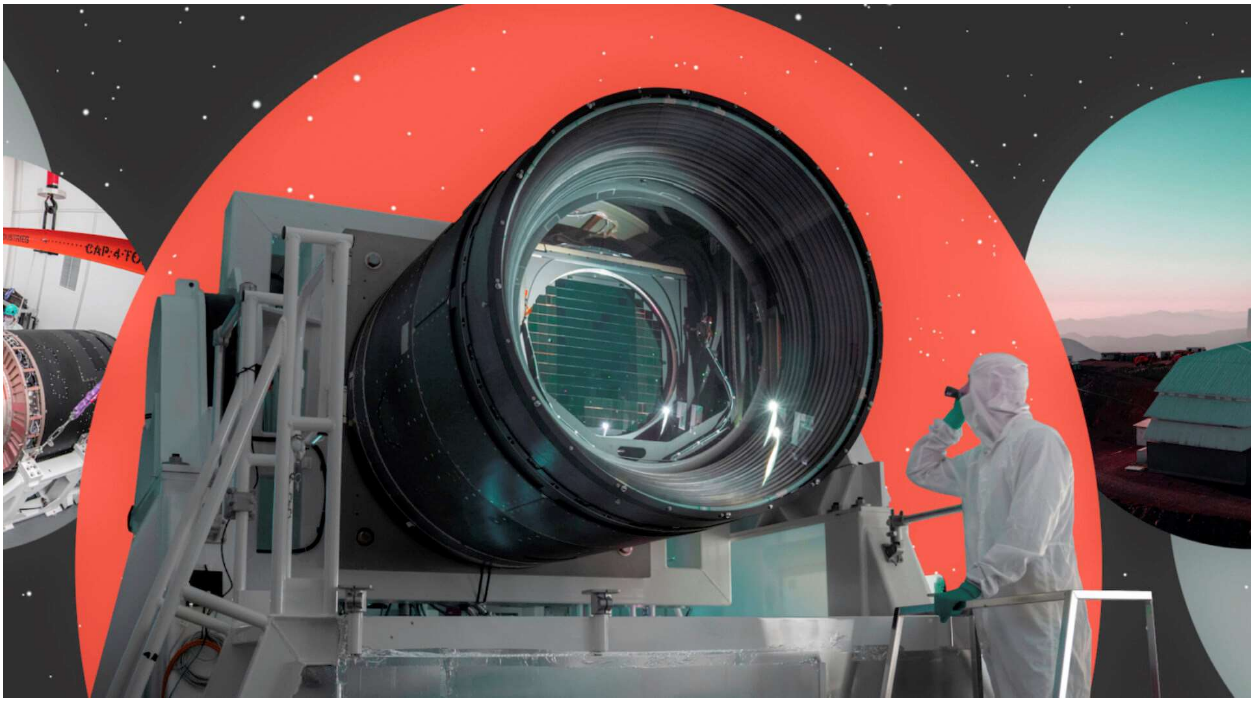


Credit: CTIO/NOIRLab/DOE/NSF/AURA. Image Processing: T.A. Rector (University of Alaska Anchorage/NSF NOIRLab), D. de Martin & M. Zamani (NSF NOIRLab)

The Rosette Nebula was recently captured by the Dark Energy Camera (DECam) to celebrate the 5th anniversary of NOIRLab, the U.S. National Science Foundation's National Optical-Infrared Astronomy Research Laboratory. The Rosette Nebula is located near one end of a giant molecular cloud in the Monoceros region of the Milky Way Galaxy approximately 5,000 light years away. It is about 5 times larger than the Great Orion Nebula. The open cluster in the heart of the nebula (NGC 2244) formed from the gas and dust of the nebula. Radiation from the young stars in the cluster (estimated at 2 million years old) has carved out a cavity in the nebula. It has also ionized the gases in the cloud that produce the colors with red representing hydrogen, gold and yellow indicating oxygen and pink from the light emitted by ionized silicon. The dark filaments are comprised of thick, cold ribbons of dust.

The DECam is mounted at the prime focus of the Víctor M. Blanco 4-meter Telescope at Cerro Tololo in Chile. It is designed to observe distant galaxies and their motion over the history of the universe. Astronomers are using this information to infer the distribution of dark energy.

Mega Eye on the Sky



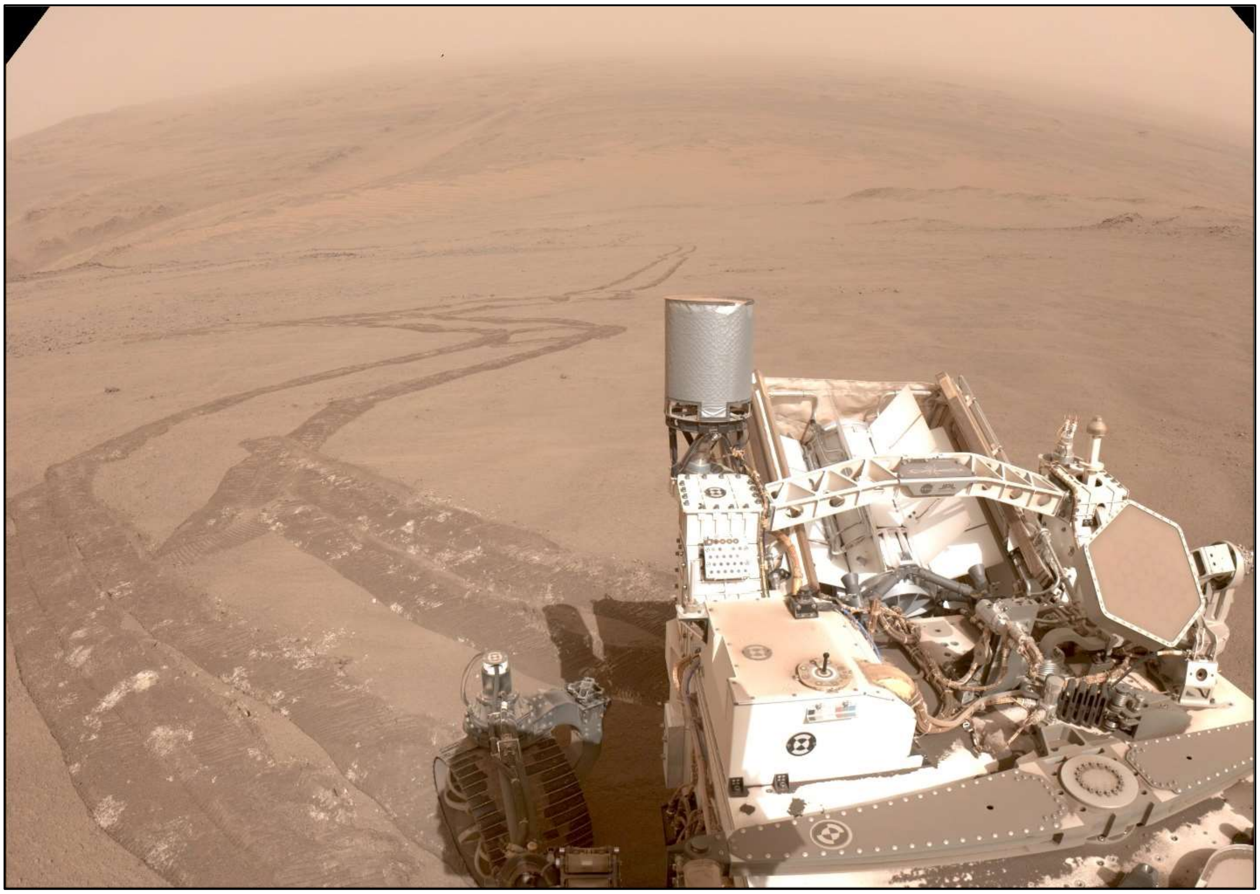
Looking into the Legacy Survey of Space and Time Camera
Greg Stewart/SLAC National Accelerator Laboratory

The largest camera ever built for astronomy and astrophysics has been delivered to the Vera C. Rubin Observatory in Chile and is ready for installation. The Legacy Survey of Space and Time Camera or LSST will image the southern hemisphere night sky over and over again for 10 years. With the 20 terabytes of data collected every night, scientists will create a map incorporating 17 billion stars in the Milky Way and 20 billion galaxies. Closer to home, the data is also expected to contain images of 6 million asteroids in our solar system.

The LSST Camera will be mounted on the Simonyi Survey Telescope, a wide field instrument with an 8.4 meter (27.5 feet) primary mirror. The camera will cover the entire sky every three nights, taking 1,000 images a night. The images will be transferred from Chile to California, where AI and algorithms will be used to search the images for any moving objects. "First Light" is currently scheduled for June 2025.

Suzanne Jacoby holding a focal plane array scale model. The CCD array will capture 3.2 gigapixel images with each image covering an area of the sky more than 40 times the apparent size of the full moon
Credit: LSST

Slippery Slope



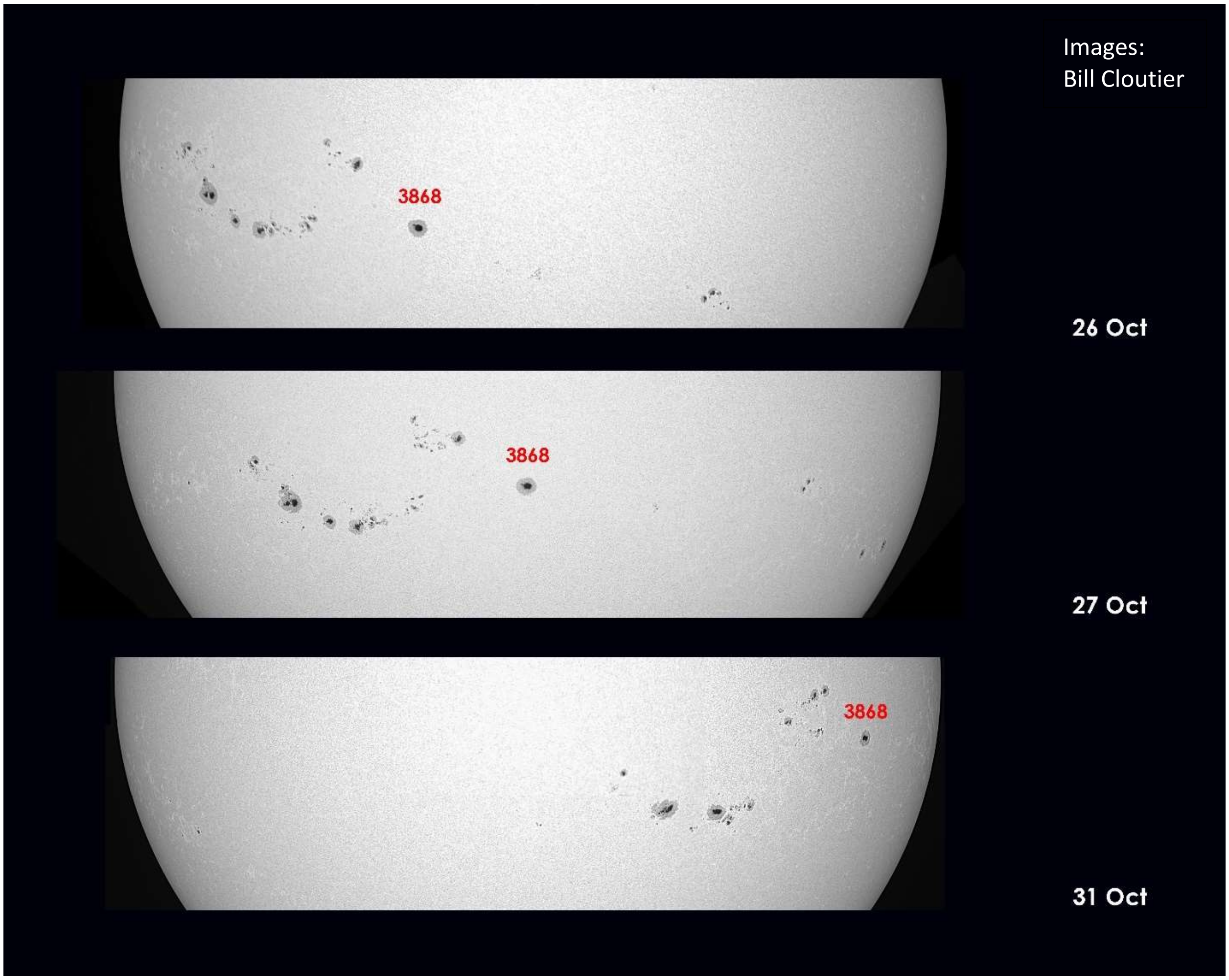
Tracks showing the wheel slippage and surface instability encountered by Perseverance
Credit: NASA/JPL-Caltech

The drive out of Jezero Crater is proving to be a greater challenge than anticipated. While the Perseverance rover has tackled steeper climbs, the ascent of the western rim has been exacerbated by a slippery surface. For most of the climb, the rover has had to navigate loosely packed dust and sand with a thin brittle crust. Progress has been slow with Perseverance achieving only half the planned distance on some days and, on one day, only a fifth.

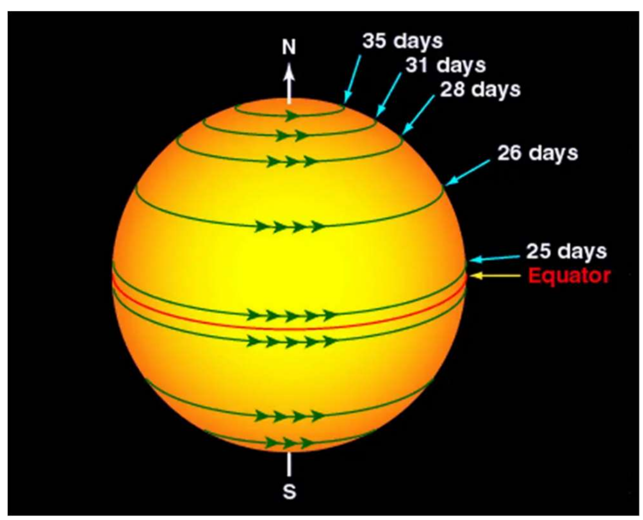
The Crater Rim Campaign, which started during the week of August 19th, is the rover's fifth science campaign since landing in February 2021. Over the first four campaigns, Perseverance collected 24 samples of rock and regolith. It has traveled 19 miles from the landing site on the crater floor, up and across the delta remnant, and along the rim of the 28 mile-wide (45 km) crater. Once it summits the rim, the rover will have gained about 1,000 feet (300 meters) in elevation. Rover drivers have been experimenting with different techniques to increase traction including driving backwards, hugging the crater wall and switch-backing.

Project scientists have already identified a number of targets to investigate on the rim including an area identified by Mars orbiters that exhibits ancient fractures that may have been produced by hydrothermal activity and a light-toned, layered bedrock that likely formed during a time when surface water was present.

Rotating Sun



The Sun is a colossal ball of gas and plasma. Unlike rocky planets and moons, its rotation varies by latitude. Galileo Galilei was the first to observe the Sun's rotation in 1612 by tracking sunspots, while Christopher Scheiner is credited with the discovery of differential rotation in 1630 (that the Sun's rotation rate is slower at higher latitudes).



Rotation rate by latitude
Image credit: NASA

The images above (captured over a five day timeframe), shows not only the Sun's rotation but the direction of rotation. Sunspots consist of a dark region (umbra), bounded by a lighter region (penumbra). The umbra in Active Region 3868 is about the size of the Earth. It appears dark because it is cooler, about 6,300°F (3,482°C), relative to the surrounding surface or photosphere (at about 10,000°F or 5,538°C). The appearance and disappearance of large sunspots can actually affect the incident net radiant energy, or "total solar irradiance," that the Earth receives.

Apollo 8 – Lookback

1968 was a year of turmoil. The United States was entangled in a war that even the Secretary of Defense concluded could not be won and he resigned from office. The My Lai massacre was one of many atrocities of the Vietnam War perpetrated by both sides during this year. Major U.S. cities were the target of race riots and anti-war protests. Chicago police violently clashed with protesters at the Democratic National Convention and civil rights leader Martin Luther King and presidential candidate Robert Kennedy were assassinated in 1968. To many Americans, the only heartening event in this otherwise horrific year was the reading from the Book of Genesis by the crew of Apollo 8 as they orbited the Moon on Christmas Eve.

The race to beat the Soviets to the Moon took a dramatic turn in 1968 and saw the United States take its first lead by year's end. Apollo 7 was launched in October 1968 into Earth orbit. A week or so later, the Soviets launched two Soyuz space craft into Earth orbit (one manned and one unmanned for a planned rendezvous). In November, another unmanned Zond flew around the Moon and photographed the unseen far side. The United States expected that the Soviets would attempt another moon shot in early December when the launch window for the Baikonur space center in Kazakhstan reopened (a Zond stood poised on the launching pad). Curiously, the opportunity passed without any activity. Cosmonaut Alexei Leonov would later attribute the Soviet's loss of initiative and resolve to the premature death of Sergei Korolev, the "Chief Designer" of the Soviet space program as well as the design complexities of their Moon rocket (the N1).

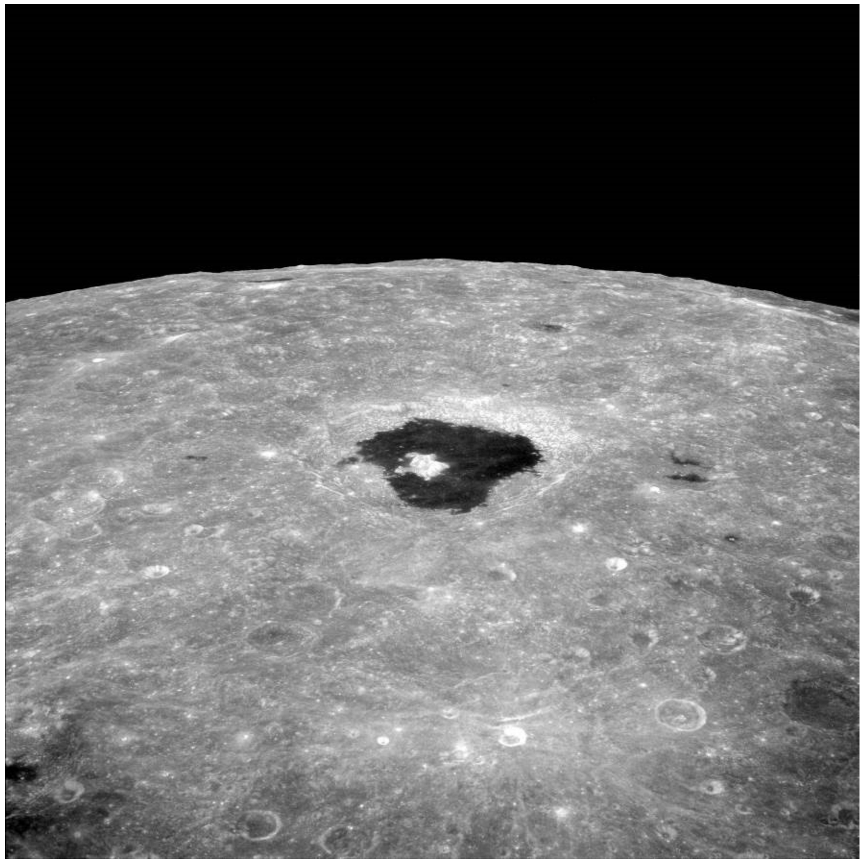
While Apollo 7 had been a successful maiden voyage of the completely redesigned command module (after the Apollo 1 fire), the United States had yet to leave Earth orbit. NASA's original plan was to launch a series of increasingly complex missions to near-Earth orbit before attempting a lunar excursion. Development of the lunar lander was behind schedule and violent vibrations in the Saturn rocket's main stage needed to be corrected before NASA felt confident of sending men to the Moon. However, the apparent progress by the Soviets threatened to upstage the United States once again. It was a proposal by a quiet engineering genius, George Low, (Manager of the Apollo Spacecraft Program Office) to send the Apollo 8 command module alone into lunar orbit that would ultimately place the United States in a position to achieve President Kennedy's goal to land a man on the Moon and safely return him to Earth by the end of the decade.

Apollo 8 was launched on December 21st under the command of Frank Borman with astronauts William Anders and Jim Lovell (Lovell replaced Michael Collins on the original team; Collins, who required back surgery, would go on to be the Command Module Pilot for Apollo 11). The launch was scheduled so that the crew would arrive at the Moon as the Sun was rising on the Sea of Tranquility. With the Sun low in the sky, the astronauts could photograph potential landing sites and resolve surface detail that would otherwise be washed out in the glare from a higher Sun.

The crew of Apollo 8 was the first to ride the three stage Saturn V rocket, with the explosive energy of an atomic bomb (the Saturn V had only been launched twice before – both unmanned). The night before the launch, the astronauts were visited by Charles Lindbergh. During the visit, it was discussed that the engines on the Saturn V would burn 10 times the amount of fuel every second that Lindbergh had used to fly nonstop from New York to Paris.

The Apollo 8 astronauts were also the first humans to leave Earth orbit and pass through the Van

Allen radiation belts that extend up to 15,000 miles from Earth. To accomplish the mission, Apollo 8 had to cross the 240,000-mile void between the Earth and the Moon with sufficient precision so as to intercept the Moon (traveling at 2,300 miles an hour through space) just 69 miles above the lunar surface. By successfully doing so, the astronauts were the first humans to witness the rising of the Earth above the Moon's horizon (Earthrise). They would also be the first to return to Earth and reenter the atmosphere at a speed of 25,000 miles an hour.



Apollo 8's view of Tsiolkovsky crater with its lava covered floor on the Moon's far side. Credit: NASA

The highlight of the mission, to many, was the broadcast from the Apollo 8 command module during the ninth orbit of the Moon. After a brief introduction of the crew and their general impressions of the lunar landscape, William Anders said that the crew had a message for all those on Earth. The astronauts took turns reading from the book of Genesis, the story of creation. Frank Borman closed the broadcast with: "And from the crew of Apollo 8, we close with: Good night, Good luck, a Merry Christmas, and God bless all of you, all you on the good Earth." It is estimated that a quarter of Earth's population saw the Christmas Eve transmission.

In order to safely return to Earth, the main engine had to be restarted on the far side of the Moon (out of contact with the Earth). If successful, Apollo 8 would reappear from behind the Moon at a predetermined time. As predicted, the spacecraft re-emerged on time, and when voice contact was regained, astronaut Jim Lovell would announce: "Please be informed, there is a Santa Claus." It was Christmas Day. Apollo 8 would return safely to the Earth two days later, splashing down in the Pacific Ocean shortly before sunrise. The astronauts and the capsule were recovered by the aircraft carrier USS Yorktown.

Following the success of Apollo 8, the Soviet Moon program fell further behind with catastrophically unsuccessful launches of their N1 booster in February and again in July of 1969. An unmanned, sample return mission attempted to upstage the Apollo 11 landing, but Luna 15 crashed into Mare Crisium shortly before Armstrong and Aldrin were scheduled to lift off from the Moon. The Soviets officially cancelled their Moon program in the early 1970s.

Purchasing a Telescope

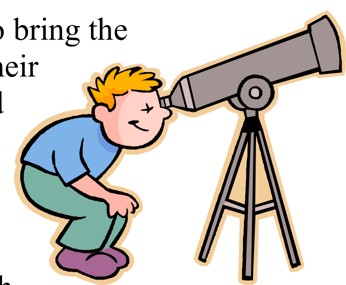
During the holidays it's not uncommon to see parents and grandparents carrying around a telescope that they just picked up at the mall or warehouse store for their budding astronomer. Unfortunately, too many of these thoughtful gifts end up in a basement or attic after one or two uses. All too often, telescope manufacturers prey on consumer's expectations, which are often out of line with the capabilities of the product, resulting in frustration and disillusionment. However, even a crudely constructed telescope can be coaxed to produce acceptable images, if the observer understands the limitations of his or her instrument.

There is no perfect telescope for everyone. An inexpensive, mass-produced telescope that gets carted out of the house and set up every clear night, stimulates the users' imagination and encourages them to push the instrument's capabilities to its limits is far more valuable than the most highly crafted optical masterpiece that spends its nights in a closet.

There are several types of telescopes available to the general consumer. Each has advantages and disadvantages, and with a little education, a consumer can find a telescope that fits his or her needs and lifestyle. Again, if you don't use it, a telescope is about as useful as a garden gnome and not as cute.

Types of Telescopes

There are three basic types of telescopes: refractors, reflectors and compound or catadioptric telescopes.



Refractors have been around for 400 years and use a series of lenses to bring the light rays from distant objects to focus. They are highly regarded for their unobstructed and high-contrast images. The optical tubes are sealed and generally more rugged than other designs. As such, the optics rarely need to be adjusted (realigned) which makes the refractor a good choice as a travel telescope. Refractors are an excellent choice for planetary and lunar viewing and for double stars, but generally do not have the large light gathering capacity needed for faint objects such as nebula and galaxies. The disadvantages of refractors include: the potential for different wavelengths of light to diverge from a common focus as they pass through the glass (producing color "fringing" around bright objects), the position of the eyepiece at the rear of the optical tube (requiring the telescope to be mounted fairly high off the ground for comfortable viewing), the closed tube that can take some time to cool down, and the price (highest cost per inch of aperture of the basic telescopes designs).

Reflectors have been around for almost as long as refractors, but use mirrors instead of lenses to bring light to the observer's eye. A large mirror located at the closed end of the optical tube reflects light back up the tube to a smaller mirror mounted near the open end and out to an eyepiece. Mirrors are much easier and less expensive to manufacture than lenses with only an optical curve required on the front of the mirror. With mirrors, the light never passes through the glass, so there is no divergence of the light rays. However, since the optical tube is open to the atmosphere, mirrors will require periodic cleaning, adjustment and, eventually, recoating. Reflectors offer the best value, particularly for larger apertures.

The most popular compound or catadioptric telescopes combine a large, rear spherical mirror with a front corrector lens to create a very compact optical tube. Companies such as Meade and Celestron built their businesses on the Schmidt-Cassegrain design. While generally more expensive than reflectors, the compound telescope offers a very portable alterative for large aperture telescopes. Disadvantages include cool down time (since the optical tubes are sealed), and a relatively large secondary mirror that degrades the image of high contrast objects (planets or the Moon). The front corrector plate is also susceptible to dew formation although this can be managed with a dew shield or corrector plate heater.

There are several terms that are used in the sales promotion of telescopes. Some of the common ones are discussed below:

Aperture

Aperture refers to the size of the largest lens or mirror in the telescope, for example, the primary mirror in an 8-inch reflector is 8-inches in diameter. As a general rule, bigger is better, as light gathering and resolution increase with the size of the optics. However, as with everything else, there are other considerations that limit the practical size of a particular instrument. Alvan Clark & Sons figured the 40-inch lens for the Yerkes Observatory's refractor, delivering the lens in 1897. More than 100 years later, it is still the world's largest working refractor. Why? The weight of the glass and the complexities in supporting a large lens by its edge and the absorption of light passing through the glass were factors; however, the refractor was ultimately done in by Sir Isaac Newton when he built the first reflecting telescope in 1668. Mirrors, unlike lenses, can be completely supported from the back. Since light does not pass through the glass, reflected images do not suffer from "chromatic aberration." Today single mirrors are routinely produced with diameters exceeding 28 feet and telescopes are constructed combining multiple mirrors to achieve even larger light gathering capabilities. So what size is good for you? Before you answer, you may want to consider:

- Are you planning on setting up your telescope in a permanent installation, e.g., backyard observatory, or will you be moving it in and out of your home every time you plan on observing? If the latter, then weight, portability and ease of set up are important considerations. Due to its size and weight, my telescope saw very little use until I invested in a wheeled platform that allows me to easily roll the fully assembled telescope in and out of my garage in minutes.

- Are you planning on taking your telescope on the road, with you on vacation or planning to travel some distance to find truly dark skies or observe a "once in a lifetime event?" Whether by train, plane or automobile, care must be taken to protect your telescope and ensure that it arrives at its destination in working order (mechanically and optically). If this is important to you, a smaller and simpler design such as a refractor may be a good choice.

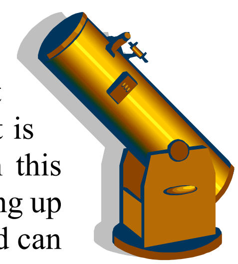
- What are you interested in looking at? Spectacular views of the Sun, Moon and planets can be acquired with a relatively modest instrument. However, if your passion is hunting down the more elusive and distant residents of the Milky Way Galaxy or exploring other galaxies far, far, away, it will require a much larger aperture to capture those meager photons.

Magnification

Magnification is likely the most overrated measure of a telescope's capabilities. Magnification is a function of the eyepiece placed in the path of the incoming light and in front of the observer's eye; the observer can change the magnification by simply selecting a different eyepiece. As such, it shouldn't be a criterion in selecting a telescope.

The limiting useful magnification is approximately 50 times the diameter of the objective lens or primary mirror. For example, a small refracting telescope with a 4-inch objective lens can be pushed to a magnification of 200 times; however, only under the best observing conditions and, in general, only on bright objects such as the Moon and planets. Most astronomers prefer the views that lower magnification provides with a wider field and brighter image. So, the next time you are captured by the stunning views of the universe on the packaging of a modest instrument, remember that the potential of most telescopes is rarely realized, particularly if you reside in the light polluted skies of the northeast. A higher power eyepiece magnifies not only the telescope's intended target but also the side-effects of living under 20 miles of Earth's atmosphere.

Mounts



While generally not at the top of the list as far as features, the telescope's mounting system and construction is key to its ease of use and the stability of the image. A poorly designed mount or one with flimsy construction can be just as frustrating to deal with as poor optics. An altitude-azimuth or alt-az mount is the simplest type of telescope mount and generally the easiest to set up. In this arrangement, the mount allows the telescope to move left and right while pivoting up and down. It is commonly found on Dobsonian* telescopes, is user friendly and can be mechanized to track celestial objects across the sky.

Another common mount design is the equatorial mount. In this design, one axis is aligned with the celestial pole, requiring only the movement around this axis to follow objects across the sky. It is the easiest configuration for tracking and is generally preferred for astrophotography. Some alt-az mounts can be converted to an equatorial configuration with the addition of an "equatorial wedge." Equatorial mounts, however, can be heavier than their alt-az counterparts.

Go-To

Essentially a computer controlled pointing system, "go-to" allows the user to select an object from a data base and command the drive motors on the mount to move the telescope to the object's location in the sky. This presupposes that the telescope user has properly set up the telescope and successfully navigated through the alignment process (a process by which the telescope's computer determines where it's pointed, the local time, and its position on the Earth). Most "go-

* Dobsonian telescopes are reflectors on a simple, swivel mount. They offer a low-cost solution for those on a limited budget with aperture fever (an insatiable desire for a larger telescope).

to" telescopes come with a large database, some of which can be modified (supplemented) by the user. While "go-to" capability is extremely convenient and can take you to thousands of objects in its database in a blink of an eye, it doesn't necessarily mean that you will be able to see the object. Depending upon the size of your telescope (see Aperture), many objects in these databases are just too dim to see with the equipment provided. CCD cameras are much more sensitive than your eye and can accumulate light for long durations. So, if you are planning on using your telescope primarily as a camera lens, then some of the disadvantage of a small aperture can be overcome. However, if you plan on doing most of your observing at the eyepiece, you may want to consider spending the money on a larger aperture rather than on "go-to" electronics.

What to Do

If you are seriously considering acquiring a telescope, a little bit of research can go a long way in enjoying your final purchase. If possible, try to observe through the telescope(s) that you are considering. Check out product reviews in trade magazines such as Sky & Telescope and Astronomy and on their websites. Contact reputable dealers and visit trade shows such as the Northeast Astronomical Forum where you can pick the brains of industry experts. Attend a McCarthy Observatory open house - when the skies are clear, up to a dozen telescopes can be found on the premises (including refractors, reflectors, a Dobsonian, and several Schmidt–Cassegrains). Compare the same celestial objects through different scopes, talk to the owners about portability, ease of setup and operation.

Saturn

Saturn reached Opposition on September 8th when the ringed-world was closest to Earth. Since that time, the distance between the Earth and Saturn has been gradually increasing with Earth's higher orbital velocity. Saturn is still well placed in the evening sky in the constellation Aquarius. The planet's north pole is currently tilted towards the Earth with its rings inclined at an angle just less than 4° to our line of sight. We see the ring tilt change (from our perspective) over Saturn's 29.5-year orbit. The last ring crossing (when the rings disappeared) was in 2009. Since then, the rings opened to a maximum of 27° before starting to close. The rings will disappear in 2025 before the process begins again, starting to open back up again, this time with the southern hemisphere tilted toward Earth.

Jupiter

Jupiter reaches Opposition this year on December 7th. By midmonth, the gas giant shines brightly in the eastern sky after sunset (almost 13 times brighter than Saturn). The largest planet in the solar system can be found in the constellation Taurus and to the east of Saturn.

	Rise and Meridian Transit Times			
	December 1 (EST)		December 31 (EST)	
Planet	Rise	Transit*	Rise	Transit*
Saturn	12:37 pm	6:08 pm	10:42 am	4:16 pm
Jupiter	4:44 pm	12:11 am	2:32 pm	9:57 pm

* The celestial meridian is an imaginary the line that connects the north and south points of the horizon with the observer's zenith (point directly overhead). A planet is highest in the sky when it crosses or transits the meridian.

Jovian Moon Transits

Jupiter's four Galilean moons are large enough to be seen with a small telescope. The orbits of the inner three moons are synchronized (orbital resonance) with Europa's orbital period twice Io's period, and Ganymede's orbital period twice that of Europa (e.g., in the time it takes Ganymede to go around Jupiter once, Europa makes two orbits and Io makes four orbits). On nights of good visibility, the shadow(s) of Jupiter's moon(s) can also be seen on the cloud tops as they cross (transit) the planet's disk. Due to the current alignment of Jupiter's and Earth's orbits, Callisto won't be transiting across the gas giant's disk until 2025.

Only events that start in the evening are included. A more complete listing can be found in Sky & Telescope's monthly magazine.

Jovian Moon Transits

Date	Moon	Transit Begins	Transit Ends
1st	Io	9:02 pm	11:14 pm
5th	Europa	10:11 pm	12:45 am (6th)
8th	Ganymede	5:36 pm	7:48 pm
8th	Io	10:57 pm	1:09 am (9th)
10th	Io	5:26 pm	7:38 pm
15th	Ganymede	9:37 pm	11:50 pm
17th	Io	7:20 pm	9:33 pm
24th	Io	9:15 pm	11:28 pm
30th	Europa	7:17 pm	9:51 pm

Great Red Spot Transits

The Great Red Spot is a large, long-lived cyclone in the upper Jovian atmosphere. The Earth-size storm will cross the center line of the planetary disk on the following evenings during the hours between 7 pm to midnight local time.

Date	Transit Time	Date	Transit Time
2nd	9:59 pm	17th	7:21 pm
4th	11:37 pm	19th	8:59 pm
5th	7:28 pm	21st	10:37 pm

Date	Transit Time	Date	Transit Time
7th	9:06 pm	24th	8:06 pm
9th	10:44 pm	26th	9:44 pm
12th	8:13 pm	28th	11:22 pm
14th	9:51 pm	29th	7:13 pm
16th	11:29 pm		

December Nights

Nights in December are not to be missed. While the often frigid and turbulent atmosphere can be frustrating for astronomers, the reflection of shimmering starlight (or moonlight) off a snow-covered landscape can be truly magical. The bright stars of the winter sky glow with color from orange to yellow to brilliant blue-white. A star-filled sky in December is unsurpassed in grandeur.

Sunrise and Sunset (New Milford, CT)

Sun	Sunrise	Sunset
December 1st (EST)	07:01	16:24
December 15th	07:13	16:24
December 31st	07:20	16:33

Astronomical and Historical Events

1st New Moon
1st History: NASA's Lucy spacecraft flies by rocky body Dinkinesh and its moon – a "contact binary" (2023)
1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
2nd Closest approach of Aten class, Near Earth Object (NEO) 2021 XZ
2nd History: Soviet Mars 3 lander became the first spacecraft to attain a soft landing on Mars, only to fail after 110 seconds (1971)
2nd History: launch of the Hayabusa 2 spacecraft to the asteroid *162173 Ryugu* from the Tanegashima Space Center, Japan (2014)
2nd History: dedication of the John J. McCarthy Observatory in New Milford, CT (2000)
2nd History: launch of SOHO solar observatory (1995)
2nd History: launch of space shuttle Endeavour (STS-61), first servicing of the Hubble Space Telescope, including the installation of corrective optics and new solar panels (1993)
2nd History: Pioneer 11 spacecraft makes its closest approach to Jupiter; encounter redirects the spacecraft to Saturn and an escape trajectory out of the solar system (1974)
2nd History: touchdown of Soviet Mars 3 lander: communications were lost with the lander, the first spacecraft to touch down on the Red Planet, after 20 seconds possibly due to raging dust storm (1971)
3rd Closest approach of Apollo class, Potentially Hazardous Asteroid (PHA) and NEO 447755 (2007 JX2)
3rd History: NASA spacecraft OSIRIS-REx arrives at asteroid *Bennu* (2018)
3rd History: Pioneer 10 spacecraft makes its closest approach to Jupiter; first space probe to fly through the asteroid belt and to an outer planet (1973)

Astronomical and Historical Events (continued)

3rd History: discovery of Jupiter's moon *Himalia* by Charles Perrine (1904)
4th Closest approach of Apollo class, PHA and NEO 2020 XR
4th Closest approach of Apollo class NEO 2021 WA5
4th History: launch of space shuttle Endeavour (STS-88), first International Space Station construction flight, including the mating of the Unity and Zarya modules (1998)
4th History: launch of the Pathfinder spacecraft to Mars (1996)
4th History: Pioneer Venus 1 enters orbit, first of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
4th History: launch of Gemini 7 with astronauts Frank Borman and Jim Lovell, spending almost 14 days in space (1965)
4th History: launch of Little Joe 2 rocket, test flight for the Mercury capsule and first U.S. animal flight with Sam, a Rhesus monkey (1959)
6th History: recovery of Hayabusa 2's sample return capsule containing material from the asteroid Ryugu (2020)
6th History: Japanese spacecraft Akatsuki enters around Venus five years after unsuccessful first attempt and main engine failure (2015)
7th History: launch of the Jason-1 satellite to measure ocean surface topography from the Vandenberg Air Force Base, California (2001)
7th History: arrival of the Galileo space probe at Jupiter (1995)
7th History: launch of Apollo 17 with astronauts Ronald Evans, Harrison Schmitt (first scientist – geologist) and Eugene Cernan (last man on the Moon – so far) (1972)
8th First Quarter Moon
8th Closest approach of Apollo class NEO 2024 UU3
8th History: launch of the Chinese Chang'e 4 spacecraft to the far side of the Moon from the Xichang, China launch site (2018)
8th History: Dragon spacecraft, launched by SpaceX into low-Earth orbit, is recovered in the Pacific Ocean: first time a spacecraft recovered by a commercial company (2010)
8th History: Japanese spacecraft IKAROS becomes the first to successfully demonstrate solar sail technology in interplanetary space during a Venus flyby (2010)
8th History: discovery of asteroid *5 Astraea* by Karl Hencke (1845)
9th History: Pioneer Venus 2 enters orbit, second of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
10th History: launch of the X-ray Multi-Mirror Mission (XMM-Newton), the largest scientific satellite built in Europe and one of the most powerful (1999)
10th History: launch of Helios 1 (also known as Helios A) into solar orbit; joint venture by Federal Republic of Germany and NASA to study the Sun (1974)
10th History: launch of the Boeing X-37B Orbital Test Vehicle 1 (unmanned space plane) from the Cape Canaveral Air Force Station (2012)
11th Closest approach of Apollo class NEO 2018 XU3
11th Closest approach of Apollo class NEO 2007 XB23
12th Moon at perigee (closest distance from Earth at 227,023 miles or 365,358 km)
12th History: discovery of Saturn moons *Fornjot*, *Farbauti*, *Aegir*, *Bebhionn*, *Hati* and *Bergeimi*r by Scott Sheppard, et al's (2004)
12th History: discovery of Saturn moons *Hyrrokkin* by Sheppard/Jewitt/Kleyna (2004)
12th History: launch of Uhuru, the first satellite designed specifically for X-ray astronomy (1970)

Astronomical and Historical Events (continued)

12th History: launch of Oscar, first amateur satellite (1961)
13th Geminids meteor shower peak
13th History: flyby of Asteroid 4179 *Toutatis* by the Chang'e 2 spacecraft, China's second lunar probe (2012)
13th History: discovery of Saturn's moons *Fenrir* and *Bestla* by Scott Sheppard, et al's (2004)
13th History: launch of Pioneer 8, third of four identical solar orbiting, spin-stabilized spacecraft (1967)
13th History: Mt. Wilson's 100-inch telescope used to measure the first stellar diameter (Betelgeuse); measured by Francis Pease and Albert Michelson (1920)
13th History: first light of Mt. Wilson's 60-inch telescope (1908)
14th Second Saturday Stars – Open House at the McCarthy Observatory (7:00 pm)
14th History: landing of China's Chang'e 3 Moon lander on Mare Imbrium (2013)
14th History: flyby of Mars by Japan's Nozomi spacecraft after an attempt to achieve orbit fails (2003)
14th History: creation of the Canadian Space Agency (1990)
14th History: flyby of Venus by Mariner 2; first spacecraft to execute a successful encounter with another planet, finding cool cloud layers and an extremely hot surface (1962)
14th History: Weston meteorite fall: first documented fall in the United States (1807); best coordinates for the fall are based upon investigative research conducted by Monty Robson, Director of the McCarthy Observatory, published in 2009
14th History: birth of Tycho Brahe, Danish astronomer noted for his observational skills, the precision of his observations, and the instruments he developed; builder of the Uraniborg and Stjenborg observatories on the Swedish island of Ven (1546)
15th Full Moon (Cold Moon)
15th History: launch of Soviet spacecraft, Vega 1 to Venus and then to Comet Halley (1984)
15th History: landing of Soviet spacecraft Venera 7 on the surface of Venus (1970)
15th History: discovery of Saturn's moon *Janus* by Audouin Dollfus (1966)
15th History: launch of Gemini 6 with astronauts Walter Schirra and Thomas Stafford (1965)
15th History: Gemini 6 and 7 execute the first manned spacecraft rendezvous (1965)
15th History: Simon Marius – first observation of the Andromeda Galaxy through a telescope (1612)
16th History: launch of the Surface Water and Ocean Topography mission for NASA (SWOT) aboard a SpaceX Falcon 9 from the Vandenberg Space Force Base, California (2022)
16th History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
16th History: birthday of futurist Arthur C. Clarke (1917)
17th Closest approach of Apollo class NEO 2022 YO1
17th History: GRAIL spacecraft impact Moon (end of mission) (2012)
17th History: Project Mercury publicly announced (1958)
17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
18th History: discovery of Saturn's moon *Epimetheus* by Richard Walker (discovery shared with Stephen Larson and John Fountain) (1966)
19th Closest approach of Aten class NEO 2020 XY4
19th History: launch of the Gaia spacecraft from French Guiana to survey more than one billion stars in an effort to chart the chart the evolution of the Milky Way galaxy (2013)

Astronomical and Historical Events (continued)

19th History: launch of space shuttle Discovery (STS-103), third servicing of the Hubble space telescope including the installation of new gyroscopes and computer (1999)
19th History: launch of Mercury-Redstone 1A; first successful flight and qualification of the spacecraft and booster (1960)
20th History: launch of the Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT); designed to measure Sun's total solar irradiance (1999)
20th History: Ames Research Center founded as the second National Advisory Committee for Aeronautics (NACA) laboratory at Moffett Federal Airfield in California (1939)
20th History: founding of the Mt. Wilson Observatory (1904)
21st Winter Solstice at 4:21 AM EST (09:21 UTC)
21st History: launch of the Soviet spacecraft Vega 2 to Venus, continued on to Comet Halley (1984)
21st History: landing of Soviet spacecraft Venera 12 on the surface of Venus, found evidence of thunder and lightning in the atmosphere (1978)
21st History: launch of Apollo 8 with astronauts Frank Borman, Jim Lovell and William Anders, first to circumnavigate the Moon (1968)
21st History: launch of Luna 13, Soviet moon lander (1966)
22nd Last Quarter Moon
22nd Ursids Meteor Shower peak
22nd History: first asteroid (323 *Brucia*) discovered using photography (1891)
23rd History: discovery of Saturn's moon *Rhea* by Giovanni Cassini (1672)
24th Moon at apogee (furthest distance from Earth at 251,335 miles or 404,484 km)
24th Parker Solar Probe makes its closest approach to the Sun, 3.8 million miles (6.1 million km) from the Sun's surface
24th History: inaugural of ESA's Ariane 1 rocket and first artificial satellite carried by an ESA rocket (1979)
24th History: the largest and best recorded meteorite fall in British history over the Leicestershire village of Barwell (1965)
24th History: Deep Space Network created (1963)
24th History: Jean-Louis Pons born into a poor family with only basic education, took post at observatory at Marseilles as concierge, went on to become most successful discover of comets (discovered or co-discovered 37 comets, 26 bear his name) (1761)
24th History: inaugural launch of the Arianne rocket, Europe's attempt to develop a cost-effective launcher to serve the commercial market (1979)
25th History: launch of the James Webb Space Telescope (JWST) from Arianespace's ELA-3 launch complex near Kourou, French Guiana (2021)
25th History: European Space Agency's Mars Express spacecraft enters orbit around Mars (2003)
25th History: landing of Soviet spacecraft Venera 11 on Venus, second of two identical spacecraft (1978)
26th History: launch of Soviet space station Salyut 4 from Baikonur Cosmodrome; third Soviet space station and second space station devoted primarily to civilian objectives; 4
27th Closest approach of Aten class NEO 2017 YD2
27th History: discovery of the ALH84001 Martian meteorite in the Allan Hills, Far Western Icefield, Antarctica, made famous by the announcement of the discovery of evidence for primitive Martian bacterial life (1984)

Astronomical and Historical Events (continued)

27th History: Johannes Kepler born, German mathematician and astronomer who postulated that the Earth and planets travel about the sun in elliptical orbits, developed three fundamental laws of planetary motion (1571)
30th New Moon
30th Closest approach of Aten class NEO 2024 AV2
30th History: flyby of Jupiter by Cassini spacecraft on mission to Saturn (2000)
30th History: discovery of Uranus' moon *Puck* by Stephen Synnott (1985)
30th History: Army Air Corp Captain Albert William Stevens takes first photo showing the Earth's curvature (1930)
31st History: GRAIL-A, lunar gravity mapping spacecraft enters orbit (2011)

Commonly Used Terms

- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth's orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm's length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)
- 1 astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station and Artificial Satellites

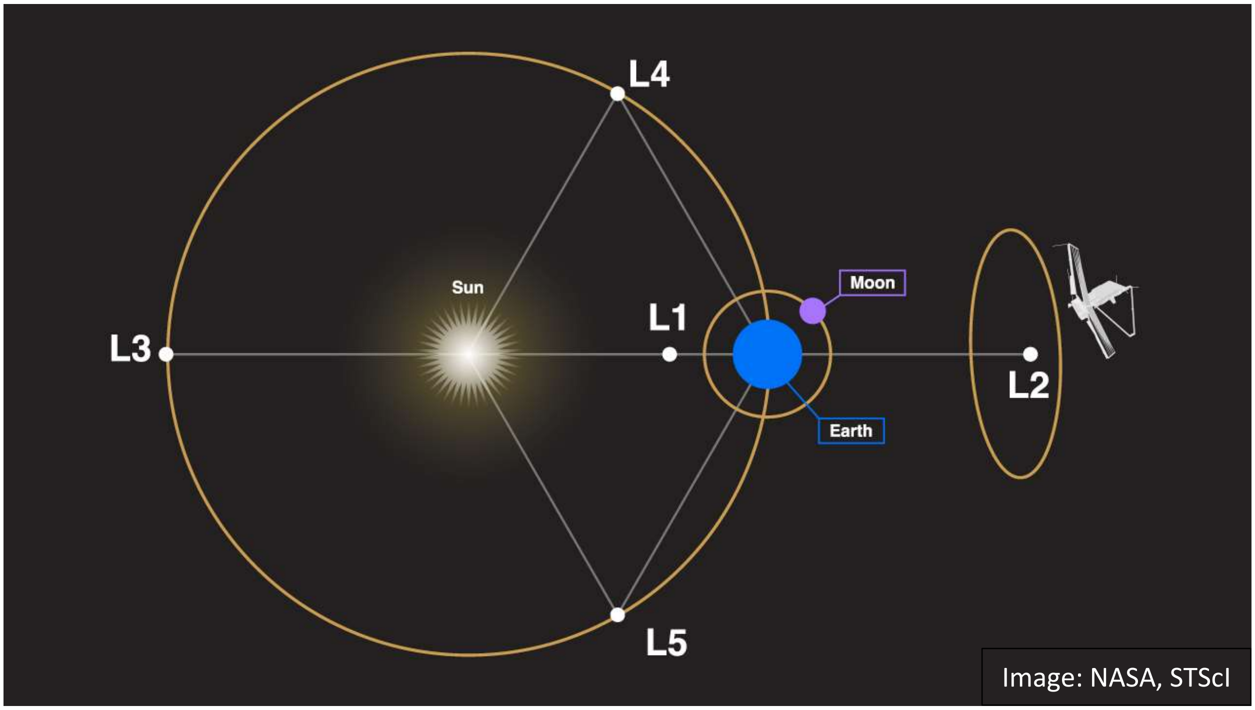
Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other man-made objects in low-Earth orbit.

Solar Activity

For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com.

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and location of the James Webb, Gaia and Euclid telescopes) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

https://webb.nasa.gov/index.html

Euclid Space Telescope

https://www.esa.int/Science_Exploration/Space_Science/Euclid

Gaia Star Surveyor
https://www.esa.int/Science_Exploration/Space_Science/Gaia

NASA's Global Climate Change Resource

- Vital Signs of the Planet: https://climate.nasa.gov/

Mars Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/
- Mars Atmosphere and Volatile EvolutioN (MAVEN): https://science.nasa.gov/mission/maven/

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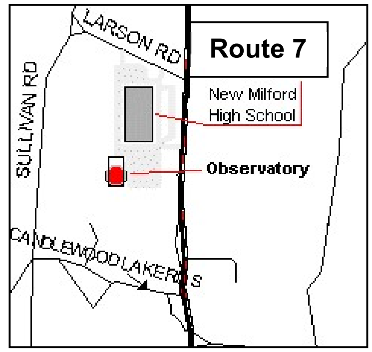

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