Galactic Observer

John J. McCarthy Observatory

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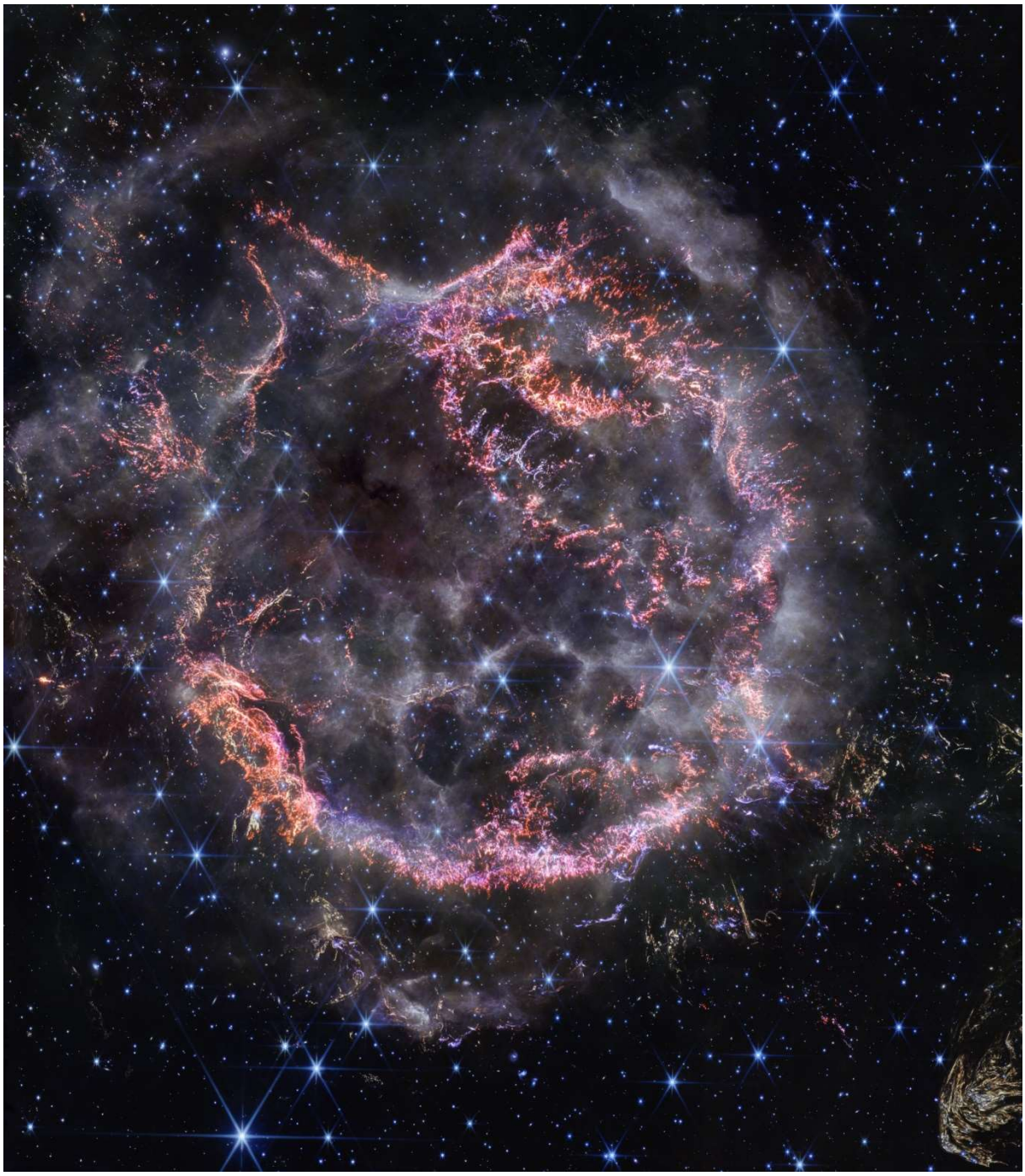
Photo of a newly discovered hydrothermal vent on the ocean floor off the coast of Ecuador. On Earth, these chimneys spew hot liquids and a cocktail of chemicals. They can be as tall as a four story building and are an oasis for a multitude of life forms. Scientists believe that ocean worlds such as Jupiter's moon Europa and Saturn's moon Enceladus could have similar structures on their rocky ocean floors. Hydrothermal vents can provide the warmth and chemical energy for primitive life forms to develop. These ocean worlds are not currently accessible with their thick icy crusts; however, engineers at JPL are designing submersibles to operate in these alien waters should a practical means of breaching the frozen shells arise.

Image credit: ROV SuBastian/Schmidt Ocean Institute

January Astronomy Calendar and Space Exploration Almanac



A new high-definition image from NASA's James Webb Space Telescope's NIRCam (Near-Infrared Camera) of the supernova remnant Cassiopeia A. An expanding shell of material, roughly 10 light-years across, or 60 trillion miles, is interacting with the gas shed by the star before it exploded. The remnant is located 11,000 light-years away from Earth.

Image Credits: NASA, ESA, CSA, STScI, Danny Milisavljevic (Purdue University), Ilse De Looze (UGent), Tea Temim (Princeton University)

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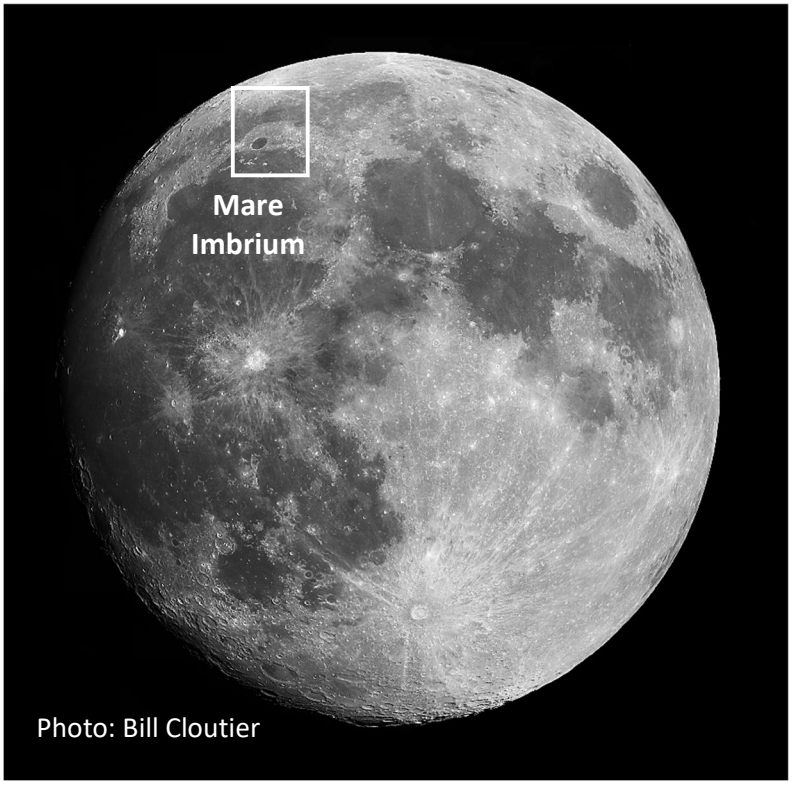
"Out the Window on Your Left"

It has been 51 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).

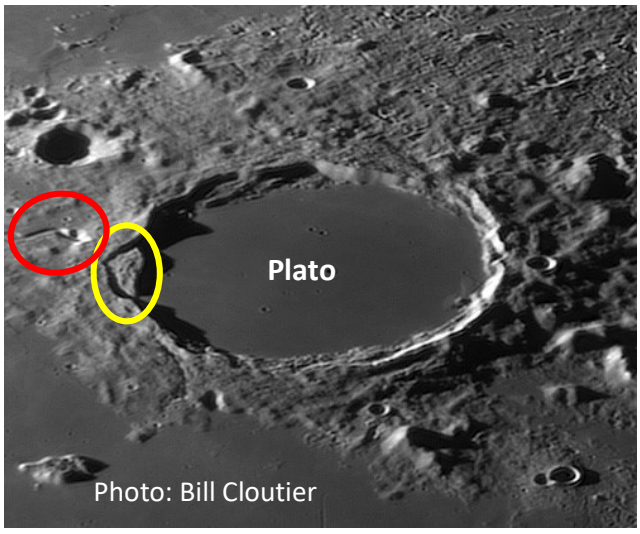
Along the rim of the Imbrium impact basin is the magnificent crater Plato, its dark, smooth floor in stark contrast to the rugged, light-colored lunar highlands. Named for the Greek philosopher, the crater rim is 63 miles (101 km) across. Its central peak, characteristic of large, complex lunar craters, is submerged in the 1.6 miles (2.6 km) of basaltic lava that fills the crater.



Location of the crater Plato (center latitude 51.62°N)

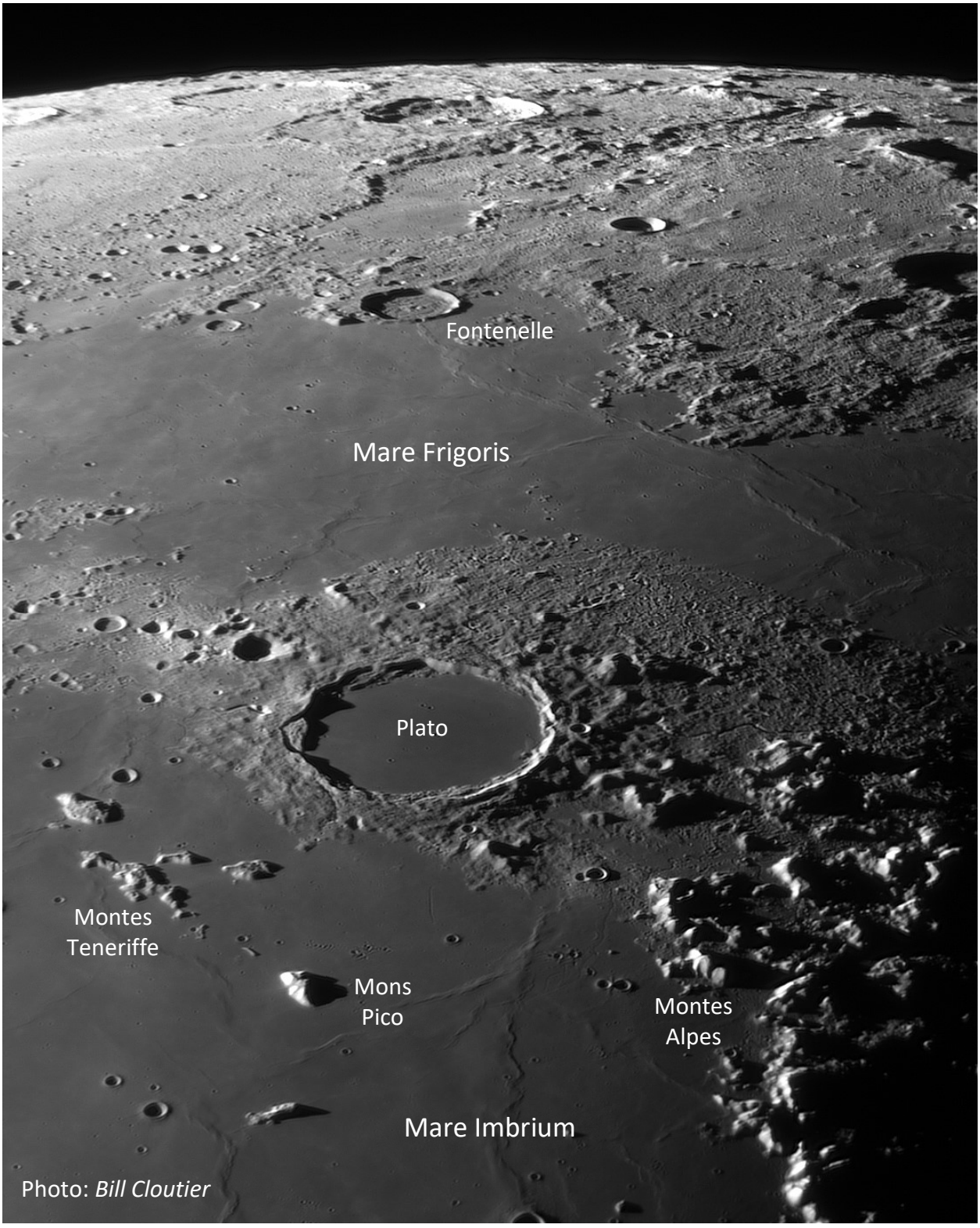
The event that created Plato crater is estimated to have occurred about a hundred million years after the Imbrium Basin impact. The crater's floor is covered with two different basalt units which differ slightly in color and composition and likely came from two separate eruptions around 2.82 billion years ago.

Few large craters dot Plato's floor. On the western rim, a roughly triangular block or massif, about 14 miles (23 km) in length, is partially disconnected from the crater rim (circled in yellow). Just to the west of this feature is a volcanic vent (circled in red).



The volcanic vent, which is about 3.5 miles (5.7 km) wide and 2700 feet (830 meters) deep, empties into an unnamed channel (called a rille) that winds west and south before flowing into Mare Imbrium. While scientists do not know when the vent was active, it likely contributed to the filling of the Imbrium basin, a process which lasted over a billion years.

Plato

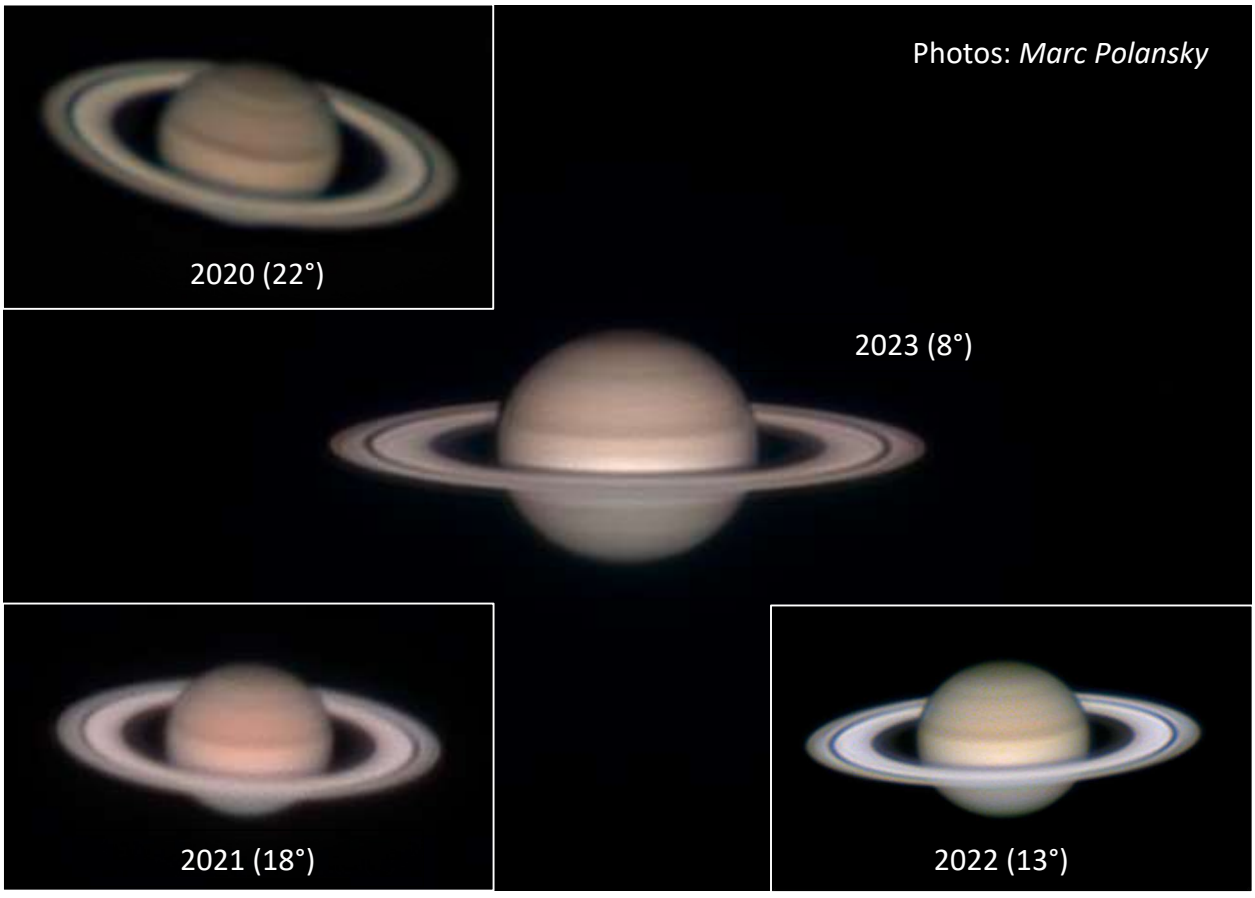

Fontenelle
Mare Frigoris
Plato
Montes
Teneriffe
Mons
Pico
Montes
Alpes
Mare Imbrium
Photo: *Bill Cloutier*

Planets in 2024

The superior planets (those that orbit further from the Sun than Earth) spend most of the first half of year in the morning sky before returning to the evening sky in the latter half of 2024. They will be at their brightest when at, or near, Opposition (when a planet is opposite the Sun in our sky). At Opposition, a planet will rise around sunset and is highest in our sky (crossing the meridian) around or just after midnight.

Saturn reaches Opposition on September 8th, 12 days later than in 2023. The ringed planet can be found in the constellation Aquarius, the Water Carrier, shinning at an apparent magnitude of +0.6. It will be 8.66 AU from Earth at that time (approximately 805 million miles or 1.295 billion km). Saturn has an axial tilt of 27°, so our view of the gas giant changes from year to year. In the coming year, the planet's rings will be tilted at an angle less than 4° to our line of sight, diminishing their splendor.

As seen from Earth, Saturn's ring tilt (the ring plane opening angle to the Earth) has been decreasing since 2017 when it was near maximum at 26°. The rings will be edge-on in March 2025 (as seen from Earth) and not at their full splendor again until May 2032. While we have been enjoying views of Saturn's north pole, after 2025 the planet's south pole will slowly come into view, as well as the underside of the rings.



In 2020, Saturn's north pole was clearly visible with its rings tilted almost 22° to our line of sight. Since then, ring tilt has steadily decreased with our view shifting to the equatorial regions. Ring tilt will decrease to less than 4° in 2024 before they disappear from view in 2025.

The rings, primarily composed of water ice, greatly contribute to Saturn's total brilliance. However, with the rings nearly edge-on, the glare from the ice is significantly reduced, making it easier to spot Saturn's dimmer moons. With the planet reaching Opposition almost two weeks later in 2024, it will also be slightly higher in the sky for observing.

Neptune reaches Opposition on September 21st. The blue ice giant can be found in the constellation Pisces the Fish. At an apparent magnitude of +7.7, you will need binoculars or a small telescope to locate the eighth planet against the background stars. At its closest, Neptune will be a distant 28.89 AUs from the Earth (approximately 2.69 billion miles or 4.32 billion km).

Uranus reaches Opposition on November 17th. The first planet to be discovered with the telescope can be found in the constellation Taurus the Bull. At an apparent magnitude of +5.6, you will need perfect viewing conditions (dark, clear skies) to spot the seventh planet. Uranus will be almost a billion miles closer than Neptune, but still a distant 18.57 AUs from the Earth (approximately 1.73 billion miles or 2.78 billion km). Only with the aid of a telescope will you be able to see the blue-green disk of this sideways-spinning planet.

Jupiter reaches Opposition, on average, every 399 days or about 33 days later each successive year. In 2024, Opposition is on December 7th when the gas giant will be 4.09 astronomical units (AU) from Earth (approximately 380 million miles or 612 million km). Jupiter will shine at an apparent magnitude of -2.8 at its brightest (only surpassed by Venus for planetary luminosity) and can also be found in the constellation Taurus the Bull, not too far from the planet Uranus.

Mercury is best seen when farthest from the Sun in Earth's sky. The finest evening views (Greatest Eastern Elongation) will occur on March 4th, July 22nd, and on November 16th. The best morning prospects (Greatest Western Elongation) are on January 12th, May 9th, September 5th, and on December 25th.

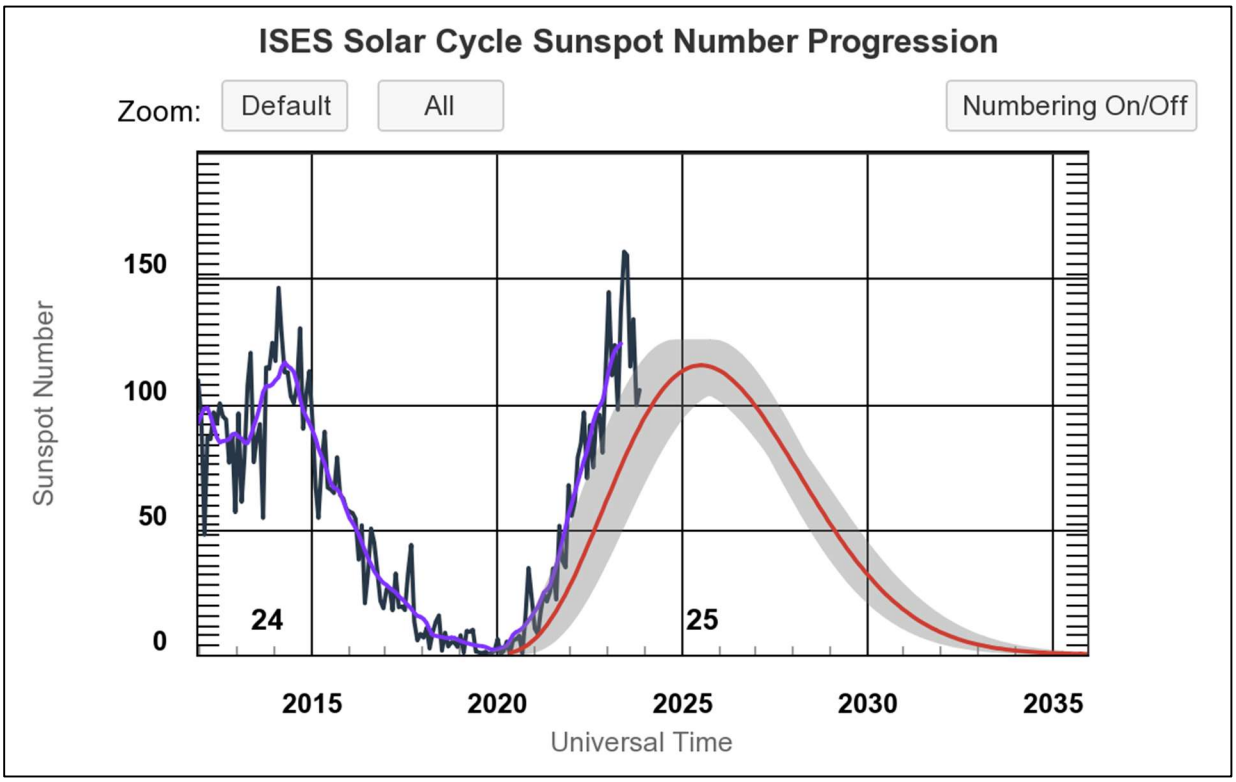
Venus reaches superior conjunction (on the opposite side of the Sun from Earth) on June 4th. Best views of our sister planet will have to wait until 2025 when the planet reaches Greatest Eastern Elongation on January 10th with a separation of 47° from the Sun in the evening sky. At -4.53 magnitude, Venus will shine brightly above the western horizon in the constellation Aquarius.

Mars reaches Opposition every 26 months. In 2022, the planets aligned on December 8th. However, while Mars will be in the evening sky during the last few months of 2024, the next Opposition won't be until January 15, 2025.

The Sun

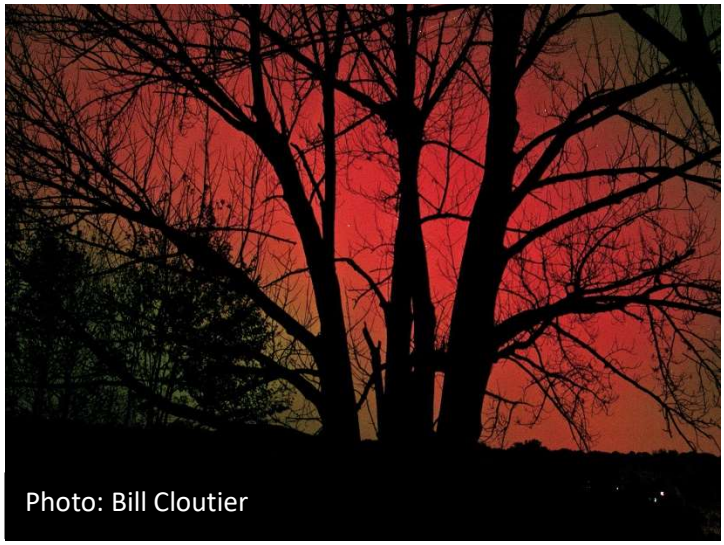
The Sun's magnetic field changes polarity approximately every 11 years: north becomes south, and south becomes north. The number of sunspots (dark areas on the photosphere) wax and wane over a similar period of time, known as the solar cycle. During the peak (number of sunspots), the Sun is more active with frequent outbursts that can produce significant space weather events, energize Earth's magnetic field and heat up its highest atmospheric layers. The heating of the thermosphere causes it to expand as it absorbs much of the X-ray and ultraviolet radiation from the Sun. While extremely diffuse, it can still increase the drag on satellites (and the International Space Station) that orbit within this layer, potentially shortening their operational life.

Solar cycles have been numbered since 1755, starting with ”Cycle 1.” We are currently in the Cycle 25, which began in December 2019 (solar minimum). The National Oceanic and Atmospheric Administration's Space Weather Prediction Center had predicted (in 2019) that solar maximum would occur sometime between December 2024 and March 2026. With a much more energetic start to the cycle, the new, updated prediction now calls for Solar Cycle 25 to peak between January and October 2024.



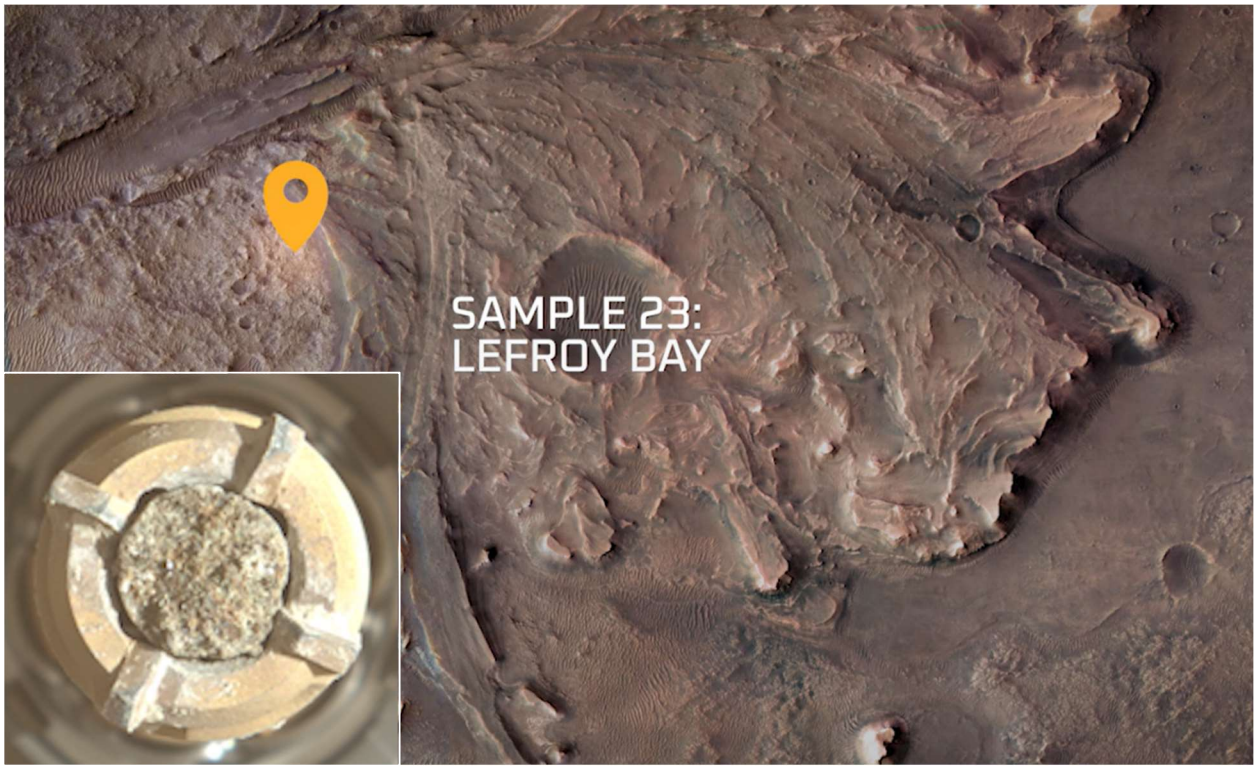
International Space Environmental Services (ISES) Space Weather Prediction Center
National Oceanic and Atmospheric Administration

Charged particles from the Sun can collide with atoms in Earth’s upper atmosphere to produce beautiful displays of light around the polar regions. This display, called aurora, typically forms 50 to 300 miles (80 to 500 km) above Earth’s surface. When the Sun is more active, auroras can be seen at lower latitudes.



Auroral display during the 2003 Halloween superstorm from New Milford. The red color was generated by collisions of electrons with nitrogen atoms, the green from oxygen collisions.

A Most Compelling Martian Sample



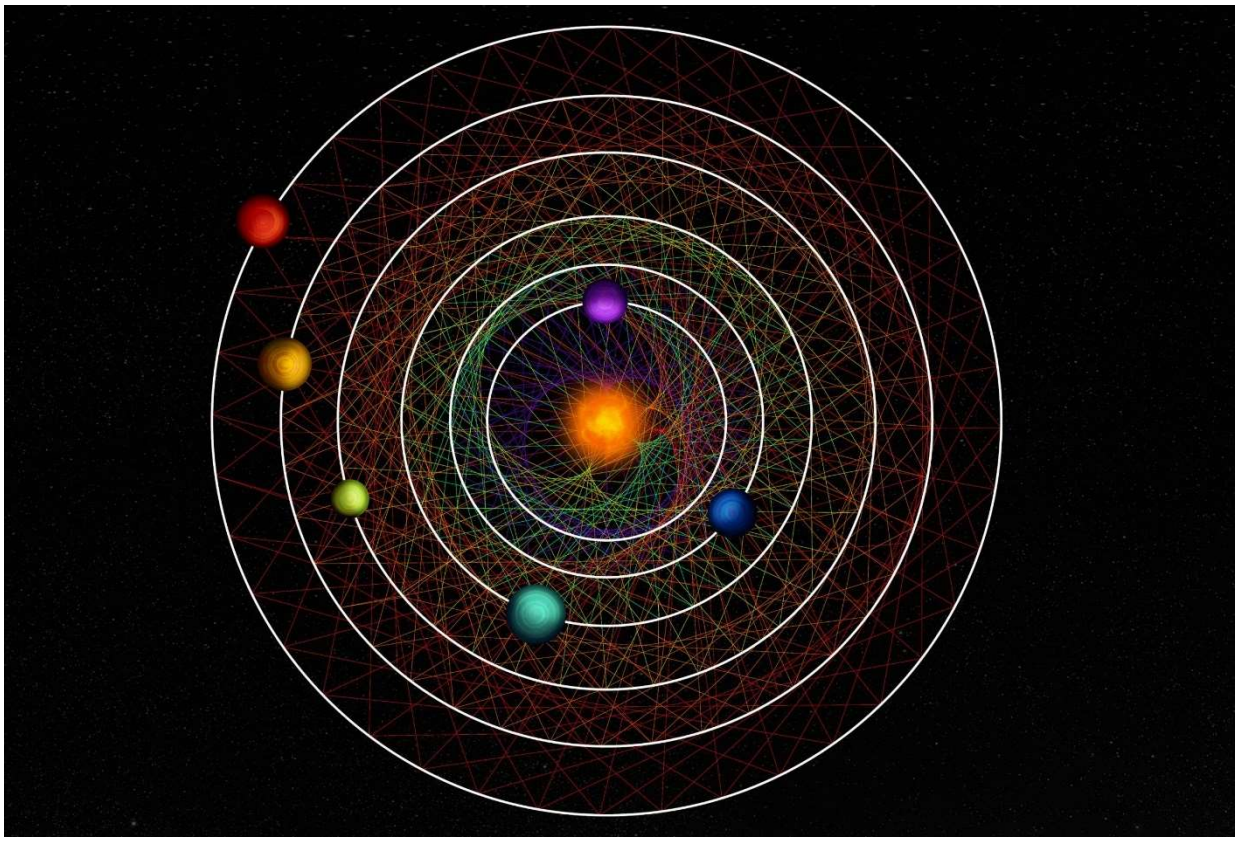
Insert: Core sample No. 23 after being extracted by the rover's rock drill and prior to being transferred into a sample storage tube - imaged by the rover's Left Mastcam-Z camera. Image Credit: NASA/JPL-Caltech/ASU

The Mars Perseverance rover may have collected its most intriguing rock sample to date. Sample No. 23 (of the 38 scheduled to be collected) was acquired from an area within Jezero Crater that is especially rich in carbonate. The rock core, called "Lefroy Bay," has an interesting and diverse surface texture and contains hydrated silica. This mineral is linked to habitability and, on Earth, has the highest potential to preserve biosignatures (ancient fossils).

Perseverance, in almost three years of exploring Jezero crater, found a crater floor made of igneous rock (from subsurface magma outbursts or volcanic activity). Covering the floor, sandstone and mudstone deposits reveal the arrival of the first river in the crater millions of years later. Above this layer are salt-rich mudstones, indicative of a shallow lake and periodic evaporation. The science team believes that this lake eventually grew as wide as 22 miles (35 km) in diameter and as deep as 100 feet (30 meters). Much later, a fast-flowing river carried boulders into the crater where they were deposited on top of the delta.

Returning the samples collected by Perseverance has been identified as one of the highest priorities by scientists in the Science and Astrobiology Decadal Survey 2023-2032. The Mars Sample Return mission, a collaboration between NASA and the European Space Agency, would be the first mission to return samples from another planet. Sample No. 23 might be one of those samples that defines an astrobiology mission and answers the question as to whether primitive life was able to establish a foothold on the Red Planet.

A Resonant Sextuplet of Worlds



Artist rendition of the six orbiting planets in the HD110067 star system
CC BY-NC-SA 4.0, Thibaut Roger/NCCR PlanetS

The European Space Agency's (ESA's) CHaracterising ExOPlanet Satellite, or Cheops, was launched in December 2019 into a Sun-synchronous orbit at 435 miles (700 km) above the Earth (a type of polar orbit that keeps the spacecraft out of the Earth's shadow). Cheops is the first mission designed to make high-precision observations of known planets around nearby stars.

In 2020 (and again in 2022), NASA's Transiting Exoplanet Survey Satellite (TESS) detected periodic changes in the brightness of the star HD110067, indicative of multiple planets crossing in front of (or transiting) the star. TESS was unable to determine the total number of planets that might be in the star system – something that researchers believed that Cheops could ascertain.

HD 110067 is a bright K0-type star located 100 light-years away from Earth in the constellation Coma Berenices. It has a mass and radius about 80% of our Sun's. Cheops not only confirmed (and discovered) the presence of multiple planets (six total), but found that the system of sub-Neptune-sized worlds were in a very rare arrangement – where all the planets are in orbital resonance with one another (e.g., the innermost planet to the star makes three full revolutions around it while the second planet makes exactly two during the same time or the outermost planet completes one orbit in the time it takes the innermost to complete six orbits). The system will likely be a future target of the James Webb Space Telescope, as the six planets appears to be gas- or water-rich with substantial atmospheres, and additional study by other researchers to unravel the mystery as to how the system's orbital configuration has endured in perfect harmony.

SunRISE

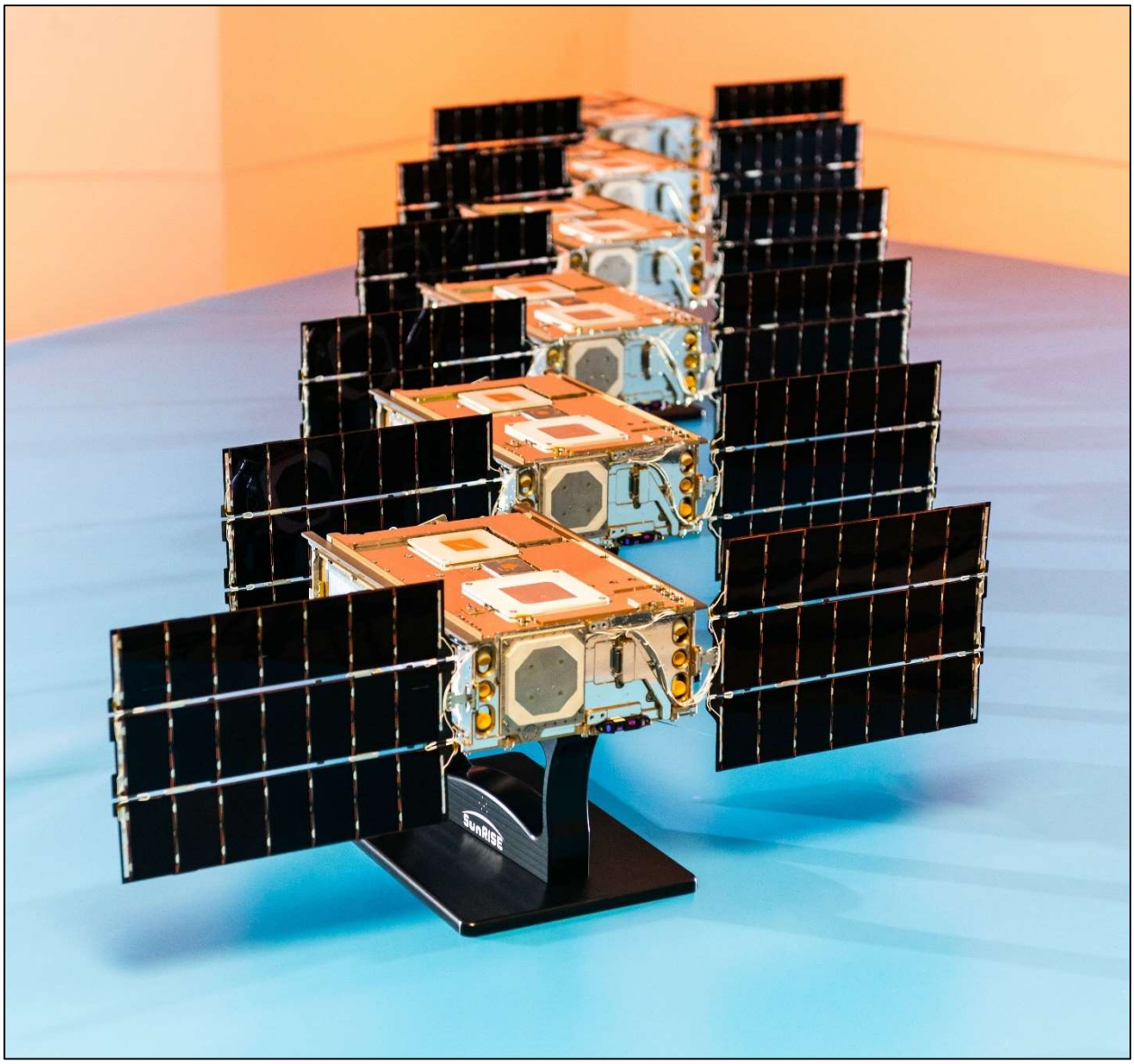
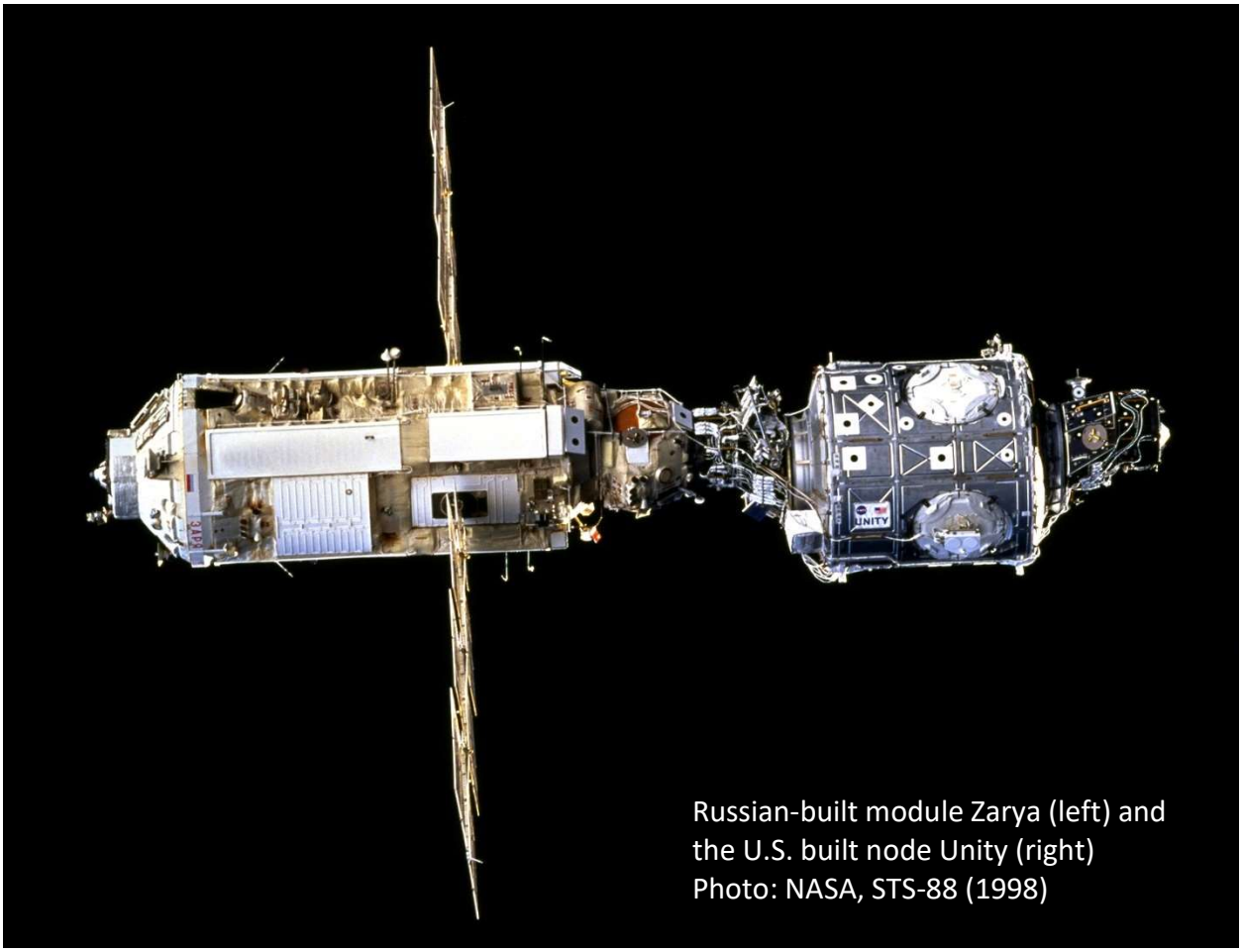


Image Credit: Space Dynamics Laboratory/Allison Bills

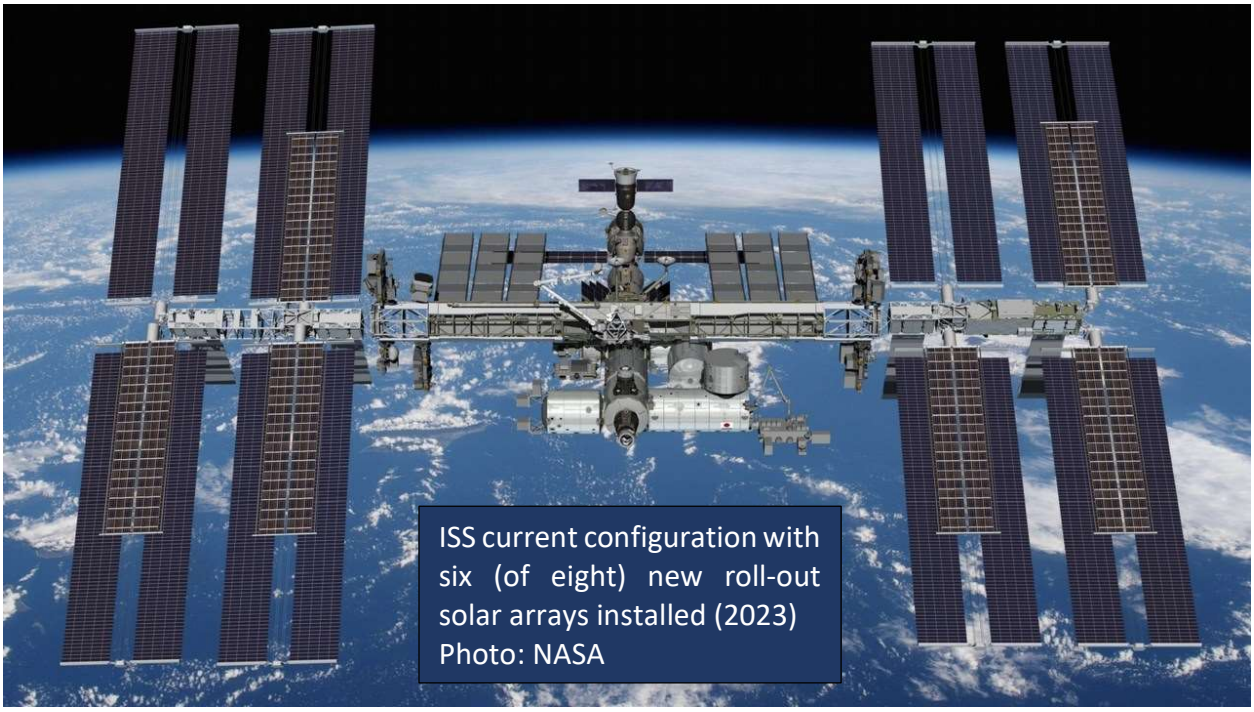
In early 2024, NASA will launch the Sun Radio Interferometer Space Experiment, or SunRISE mission. Comprised of six toaster-size CubeSats, the tiny spacecraft will be positioned within 6 miles (10 km) of one another in high-Earth orbit. Working together, they will act like a giant, single-aperture radio telescope to study solar activity.

The SunRISE CubeSats will observe low radio frequency emissions from solar particle storms that can pose a threat to both spacecraft and astronauts. These emissions are blocked by the Earth's upper layer of atmosphere (ionosphere) so the spacecraft will make their observations from an altitude slightly above geosynchronous orbit at 22,000 miles (35,400 km). The Sunrise mission should aid scientists in their forecasts of space weather and add to our understanding of how solar activity affects planetary environments and habitability (not only in our solar system but planets around other stars as well).

25 Years



Russian-built module Zarya (left) and the U.S. built node Unity (right)
Photo: NASA, STS-88 (1998)



ISS current configuration with six (of eight) new roll-out solar arrays installed (2023)
Photo: NASA

In the President's 1984 State of the Union Address, Ronald Reagan directed NASA to build an international space station within the next 10 years. The first segment; however, wouldn't be launched until the end of 1998 when the Russian Zarya module was placed into orbit. Thirty-six space shuttle flights and five Russian launches were required to complete the station - the last major components were delivered by the space shuttle Atlantis in 2011.

The start of continuous occupation of the International Space Station (ISS) began on November 2, 2000 when a Russian spacecraft Soyuz TM-31 delivered the Expedition 1 three-person crew (astronaut Bill Shepherd and cosmonauts Yuri Gidzenko and Sergei Krikalev) to the station. In 2000, the journey from launch pad at the Baikonur Cosmodrome to the ISS took two days – in October 2020, with continuous improvements in rendezvous techniques, a Soyuz spacecraft arrived at the ISS in just three hours.

In 2000, the ISS consisted of the Russian Zarya cargo and Zvezda service modules, U.S. Unity module and the Z1 (Zenith) truss that would be one of the future attachment points for solar arrays, thermal control radiators and external payloads. During the crew's 136-day stay (which ended in March 2001), station construction accelerated with components and equipment delivered by three space shuttles and two Russian Progress resupply vehicles. The first set of solar arrays was installed in December 2000 and the Destiny Laboratory Module, the primary research laboratory for the U.S., in February 2001. The European Space Agency's Columbus Laboratory module and the first Japanese Kibo laboratory module joined the station in 2008. Astronauts and cosmonauts have conducted more than 227 spacewalks in support of space station construction and maintenance since 1998.

The completed station is 357 feet (109 meters) from end to end (about the size of an American football field including the end zones). Orbiting about 250 miles (402 km) above the Earth at 17,500 mph (28,000 km/hour), astronauts experience 16 sunrises and sunsets, on average, every 24 hours; however, at that speed each one lasts only a few seconds. Four pairs of solar arrays, each spanning 240 feet (73.2 meters), provide 70 to 90 kilowatts of power for station operations. The station's habitable volume is 13,696 cubic feet (388 cubic meters), not counting visiting vehicles (eight spacecraft can be connected to the station at once). An international crew of six typically live and work on the station, hosting almost 3,000 research investigations from scientists and researchers in more than 100 countries. Areas of investigation include biology and biotechnology, Earth and space science, educational activities, human research, physical science and technology development. In 2005, Congress designated the U.S. portion of the station as a national laboratory to encourage its use by academic and private institutions.

The station is showing its age and NASA has recently embarked on a program to upgrade the power collection system (the first pair of solar arrays have been in operation since December 2000) which is showing signs of degradation. NASA has now installed six of eight new and smaller (but more efficient) roll-out solar arrays to supplement the existing, larger arrays. Positioned in front of the current arrays, the new units will use the existing sun tracking, and power distribution systems. Fully integrated, they will provide a 20% to 30% increase in power for station operations – comparable to the power production of the original arrays when new.

The United States, Japan, Canada, and the participating countries of ESA (European Space Agency) have confirmed they will support continued space station operations through 2030. Russia has agreed to support the station through 2028.

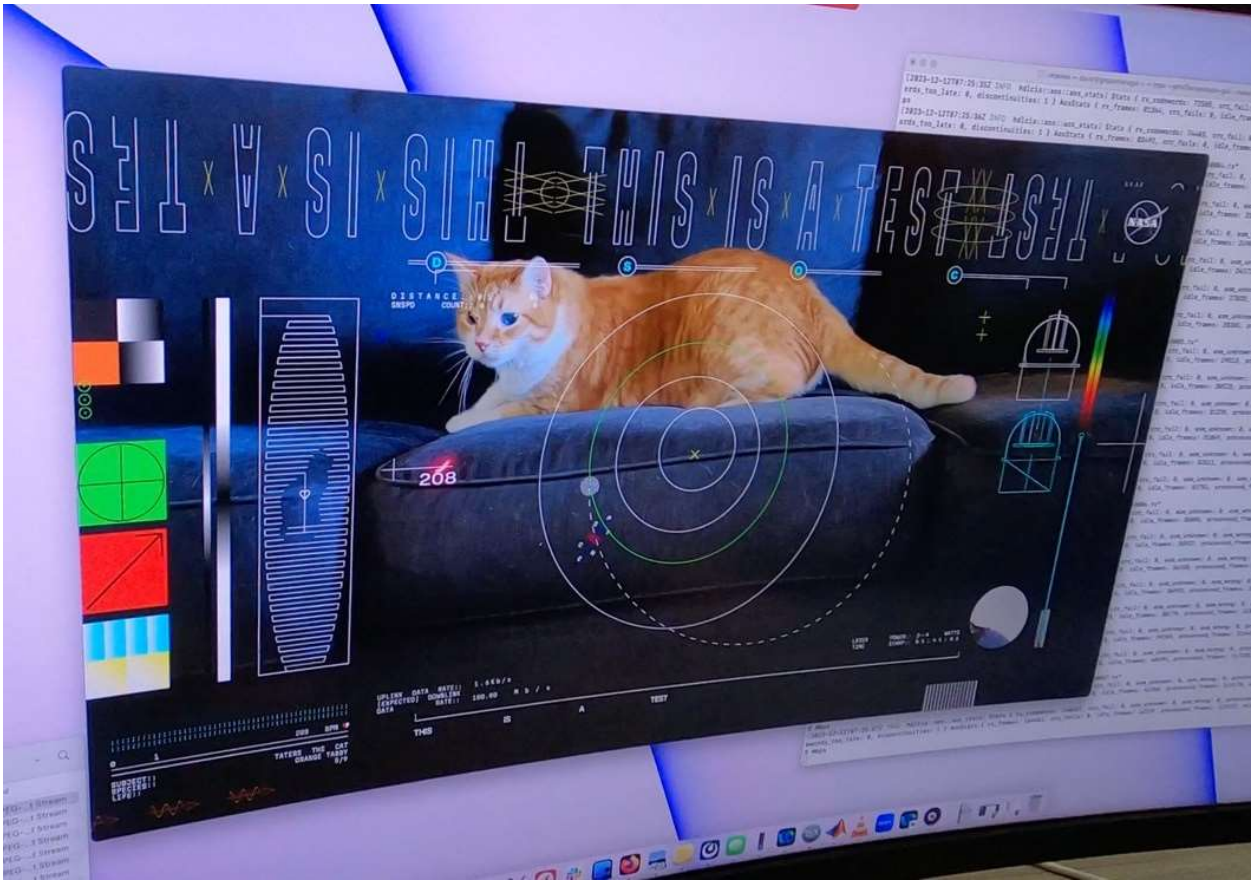
Deep Space Communication Demonstration

The DSOC flight laser transceiver, distinguished by its prominent tubular sunshade, is mounted on the side of the Psyche spacecraft. The photo was taken during launch preparations.
Image credit: NASA/JPL-Caltech

Riding along with NASA's Psyche spacecraft, which was launched on October 13th, was the Deep Space Optical Communications (DSOC) experiment. The technology demonstration, which will be conducted over first two years of Psyche's six-year deep space journey to the outer asteroid belt, is configured to send high-bandwidth test data to Earth using its 4-watt, near-infrared laser. It will also receive data using a photon-counting camera. The experiment expects to demonstrate data transmission rates 10 to 100 times greater than the state-of-the-art radio frequency systems in use today by spacecraft. While optical communications have been demonstrated in low-Earth orbit and at lunar distance, DSOC is the first to test the method in deep space.

On November 14th, DSOC's receiver locked onto a laser beacon transmitted from NASA's Jet Propulsion Laboratory's (JPL) Table Mountain Facility near Wrightwood, California. The uplink helped the DSOC transceiver aim its downlink laser back to the 200-inch (5.1-meter) Hale Telescope at Caltech's Palomar Observatory in California, approximately 100 miles (130 km) south of Table Mountain (all the while the spacecraft continued to move and Earth rotate). While "first light" was from a relatively modest distance of 10 million miles (16 million km), the technology has the potential of revolutionizing spacecraft communication methods.

Since "first light," the system has achieved faster data downlink speeds and increased pointing accuracy. On the night of December 4th, the science team was able to download a total of 1.3 terabits of data (more than the 1.2 terabits of data downlinked during the entire four-year mission of NASA's Magellan spacecraft to Venus).



A computer screen in JPLs' mission support area showing Taters the cat from the first high-definition streaming video to be sent via laser from deep space
Credit: NASA/JPL-Caltech

On December 11th, DSOC achieved another first when it transmitted an ultra-high definition streaming video from 19 million miles away (31 million km). The 15-second test video was sent at the system's maximum bit rate of 267 megabits per second (Mbps) and featured an orange tabby cat named Taters (the pet of a JPL employee) chasing light from a laser pointer.

The fun video was uploaded to the spacecraft before launch for the demonstration, since none of the instruments on Psyche generate video data, and overlaid with graphics such as Psyche's orbital path, Palomar's telescope dome, and technical information about the laser and its data bit rate. Tater's heart rate, color, and breed were also displayed.

Despite the distance over which the data was transmitted, DSOC was able to send the video to Palomar faster than Palomar was able to forward it to JPL over the internet. The technology promises higher-data-rate communications for future missions, including the transmission of complex scientific information and high-definition imagery when humans return to the Moon or travel to Mars.

When the Wind Disappears

NASA's MAVEN spacecraft
Credits: NASA/GSFC

NASA's MAVEN (Mars Atmosphere and Volatile EvolutioN) spacecraft has been observing the upper atmosphere of Mars since its arrival around the Red Planet in September 2014. Its mission is to aid in our understanding of the changes that have occurred in the Martian atmosphere and climate over time (from a world that was warm and wet in the distant past to today's cold and arid environment).

The Martian magnetosphere and ionosphere is under a relentless assault by the solar wind (a stream of charged particles originating from the Sun). In December 2022, MAVEN observed an extremely rare event which transpired when a stream of faster-moving solar wind overtook a stream of slower moving solar wind, compressing the two regions together and leaving a void of extremely low-density solar wind behind. With the sudden "disappearance" of the solar wind (and the pressure it exerted), the Martian atmosphere and magnetosphere expanded by thousands of miles, more than tripling in size.

The event temporarily pushed out the Sun's magnetic field, which is typically embedded within the Martian ionosphere. This transformed the atmospheric layer from a magnetized state to an unmagnetized state. This was the first time that MAVEN has observed such a phenomenon and, while other spacecrafts orbiting Mars (and Earth) were able to detect certain aspects of the event, only MAVEN was able to monitor both the Sun's activity, as well as the response by the planet's atmosphere.

The happenstance gave scientists a glimpse of the Martian environment without the solar wind, as well as what a planet like Mars would be like if it were orbiting a much quieter star.

Jupiter this Month

Jupiter reached Opposition (and closest to Earth) on November 3rd. At the beginning of January, the gas giant shines brightly in the southern sky shortly after sunset as Saturn sets in the southwest. The largest planet in the solar system can be found in the constellation Aries.

		Rise and Meridian Transit Times				
	January 1 (EST)			January 31 (EST)		
Planet	Rise	Transit*	Set	Rise	Transit*	Set
Jupiter	12:37 pm	7:24 pm	2:10 am	10:43 am	5:32 pm	12:21 am

* 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
5th	Io	9:49 pm	11:58 pm
6th	Europa	7:36 pm	9:55 pm
6th	Ganymede	9:20 pm	10:58 pm
7th	Io	4:18 pm	6:27 pm
12th	Io	11:45 pm	1:54 am (13th)
13th	Europa	10:12 pm	12:31 am (14th)
14th	Io	6:14 pm	8:23 pm
21st	Io	8:10 pm	10:19 pm
28th	Io	10:06 pm	12:15 am (29th)
30th	Io	4:35 pm	6:44 pm
31st	Europa	4:42 pm	7:01 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
1st	10:56 pm	18th	10:02 pm
4th	8:26 pm	20th	11:41 pm
6th	10:05 pm	21st	7:32 pm
8th	11:44 pm	23rd	9:11 pm
9th	7:35 pm	25th	10:50 pm
11th	9:14 pm	28th	8:21 pm
13th	10:53 pm	30th	10:00 pm
16th	8:23 pm		

Explorer 1

Sixty-six years ago, on January 31, 1958, the United States successfully launched its first satellite, Explorer 1. The launch occurred during the International Geophysical Year, a global initiative which actually ran from July 1957 to December 1958 and coincided with the peak in the 11-year solar cycle. Unlike Sputnik 1, which had been launched by the Soviet Union in October of 1957 and designed to only broadcast radio pulses (or Sputnik 2 which carried a dog into space as a crude biological demonstration), Explorer 1 carried a suite of instruments to study cosmic rays, micrometeoroids, and the satellite's temperature. It was the first artificial satellite designed to return scientific data.

The launch of Explorer 1 followed the unsuccessful launch of a U.S. satellite on a Navy Vanguard rocket in December (the rocket fell back to the pad and exploded shortly after liftoff). Following the humiliating loss of Vanguard, which was widely publicized by the Soviets, the competing Army's rocket team (headed by Wernher von Braun) offered their Jupiter C ballistic missile as an alternative launch vehicle. Teamed with the Jet Propulsion Laboratory (JPL) which designed and constructed the satellite and James Van Allen who designed the cosmic ray detector, the 31-pound (14 kg) satellite was successfully placed into an orbit around Earth with an apogee of 1,563 miles (2,515 km) and a perigee of 220 miles (354 km).

L to R: Pickering, Van Allen and von Braun
Credit: NASA

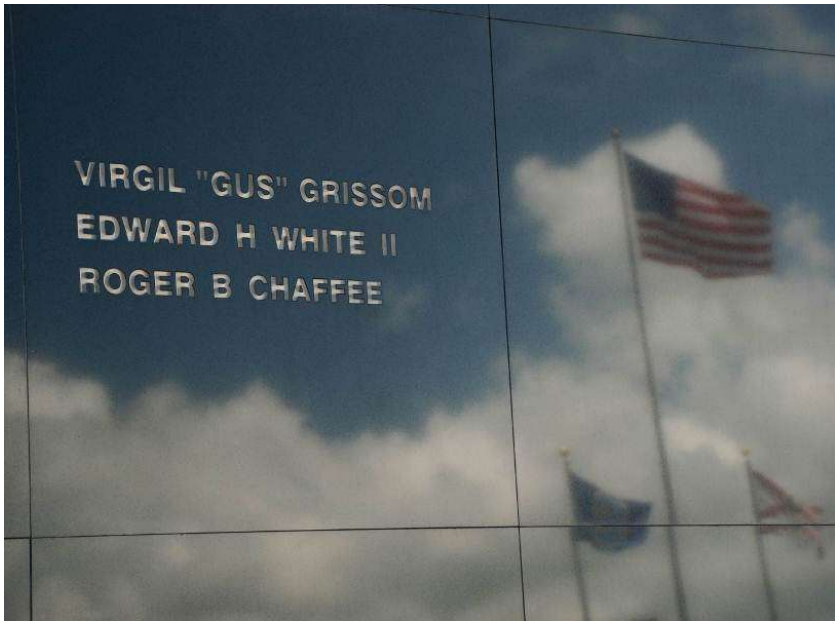
During a 1:00 am press conference at the National Academy of Sciences on February 1, shortly after the successful night launch of Explorer 1, the three team leaders Bill Pickering (JPL), James Van Allen (State University of Iowa) and Wernher von Braun (Army's Redstone Arsenal) celebrate by holding aloft a model of the satellite.

Explorer 1 would end up completing more than 58,000 orbits before reentering the Earth's atmosphere on March 31, 1970. The lower-than-expected counts recorded by the cosmic ray detector led Van Allen to theorize that the instrument had been affected by charged particles trapped by the Earth's magnetic field. The existence of two and sometimes three toroidal "radiation belts" encircling the Earth were later confirmed by subsequent missions and named the Van Allen Belts.

In August 2012, NASA launched the Van Allen Probes to study this dynamic region of space (http://vanallenprobes.jhuapl.edu/). With two identical spacecraft, traveling in tandem, scientists were able to measure changes in the belts over time and space. The probes have provided researchers a new understanding of how the belts respond to fluctuations in the Sun's output. The two-year mission was later extended to seven years as the probes continued to return ground-breaking results. The orbits of the two probes were lowered in 2019, before they ran out of fuel, to ensure that they would eventually burn up in the Earth's atmosphere and not add to the growing orbital debris fields that pose hazards to spacecraft and space travelers. NASA's mission to explore Earth's radiation belts ended when ground controllers shut down the first probe in July 2019 and the second in October.

January History

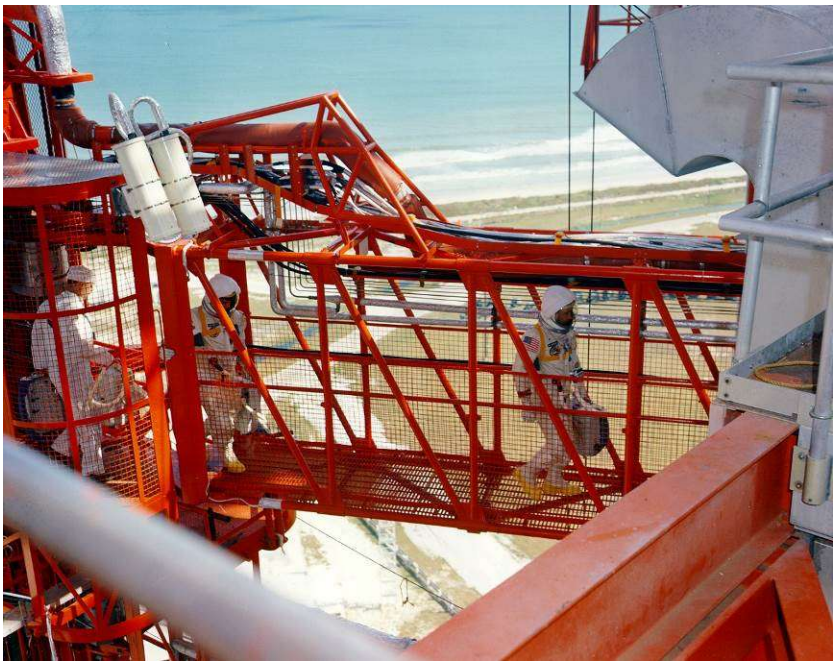
The month of January has been a difficult one for both the American and Soviet space programs. Untimely deaths set back both the American and Soviet moon programs. The two space shuttles that have been lost were also launched in January.



Space Mirror Memorial on the grounds of the Kennedy Space Center Visitor Complex Photo: Bill Cloutier

Sergei Korolev, the "Chief Designer" of the Soviet space program, died on January 14, 1966 from a botched medical procedure. Korolev co-founded the Moscow rocketry organization in the 1930s before being thrown into prison during the peak of Stalin's purges. He spent a year in the Kolyma gold mine, the most dreaded part of the Gulag in Siberia before he was recalled to Moscow to aid the Red Army in developing new weapons. Korolev went on to lead the Soviet space effort. Unfortunately,

the Soviet Moon program died with Korolev in 1966. While the race continued for some time after his death, his N-1 moon rocket never made a successful flight.



The crew of Apollo 1 crosses the gantry to the spacecraft on the day of the fire, Jan. 27, 1967 Credit: NASA

In January of 1967, after a successful conclusion to the Gemini program, NASA was moving forward with testing the new Apollo spacecraft. On the afternoon of the 27th, Gus Grissom, Ed White and Roger Chaffee were sealed inside the Apollo 1 command module sitting on top of an unfueled Saturn rocket in a simulated countdown. The command module had been plagued with problems and was in a state of constant redesign. At 6:31 pm, a spark from a damaged wire ignited the pure oxygen atmosphere in the spacecraft. Within seconds the temperature reached 2,500°. The astronauts never had a chance to undo the bolts of the hatch before they were asphyxiated. Following their deaths, the spacecraft was completely redesigned. Lessons learned from this accident served to make the spacecraft much safer and contributed to the success of the six moon landings.

Thirty-six years ago, on January 28, 1986, the United States lost its first space shuttle, the Challenger. Due to the low temperature on the launch pad, a rubber-like O-Ring used to seal the joints of the solid rocket boosters failed to seat and stop the hot gasses from escaping. The gas produced a blowtorch-like flame that penetrated the external tank filled with liquid oxygen and hydrogen. The tank exploded 73 seconds after liftoff, destroying the shuttle and killing all seven crew members. Among the crew was Christa McAuliffe, a New Hampshire teacher. Christa graduated from Framingham State College (Framingham, Massachusetts) in 1970. Following her death, the college established *The Christa McAuliffe Center* on the campus as a means to continue the educational mission which was Christa's life's work.

On February 1, 2003, a second space shuttle, the Columbia, was lost. The Columbia was the oldest shuttle in the fleet, having been first flown in 1981 by astronauts John Young and Robert Crippen. On its 28th flight, Columbia broke apart during reentry at an altitude of some 200,000 feet and a speed of 12,500 miles per hour. The shuttle and its crew of seven had just completed a 16-day science mission. The most likely cause of the accident was damage to a seal on the left wing from a piece of insulating foam that broke loose from the external fuel tank at launch, striking the wing. The resulting gap in the wing allowed the superheated atmosphere to penetrate the wing during reentry and destroy the spacecraft. The Columbia accident ultimately led to the decision to stop flying the space shuttle once the International Space Station was complete and spurred efforts to develop a safer manned vehicle.

The "Forever Remembered" memorial in the Space Shuttle Atlantis exhibit at the Kennedy Space Center Visitor Complex in Florida. Visitors entering the darkened room will see a section of the fuselage recovered from space shuttle Challenger (left) and the flight deck window frames recovered from the space shuttle Columbia.

Photo: Bill Cloutier

January Nights

January nights can be clear and cold with frigid blasts of polar wind. They also present an opportunity to see stars at every stage in their life cycle, from birth (Orion Nebula) to fiery demise (Crab supernova remnant).

If you are out observing the open star clusters Pleiades or Hyades (in mythology, half-sisters to the Pleiades) in the constellation Taurus, don't overlook the orange-colored star Aldebaran (spectral type of K5 with a surface temperature of 4,010° K as compared to the Sun's 5,780° K temperature). While not part of the Hyades cluster (which is more than twice as far away as the red giant), the "eye of the bull," and the brightest star in Taurus, is estimated to be about 67 light years away and the fourteenth brightest star in our sky.

Sunrise and Sunset (from New Milford)

Sun	Sunrise	Sunset
January 1st (EST)	07:20	16:33
January 15th	07:18	16:48
January 31st	07:06	17:07

Astronomical and Historical Events

1st Moon at apogee (furthest distance from Earth)
1st History: flyby of the Kuiper Belt Object 486958 *Arrokoth* (2014 MU69) by the New Horizons spacecraft (2018)
1st History: GRAIL-B spacecraft enters lunar orbit (2012)
1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, *Ceres* (1801)
2nd Earth at Perihelion – closest distance from Sun (0.983 AU)
2nd Closest approach of Near-Earth Object and Apollo class asteroid (2019 KK5)
2nd History: flyby of comet *Wild 2* by the Stardust spacecraft (2004)
2nd History: launch of the Soviet spacecraft Luna 1; first probe to fly by the Moon (1959)
3rd Last Quarter Moon
3rd History: exploration rover Spirit lands on Mars in Gusev Crater; operational for six years before getting bogged down in loose soil at a winter haven called Troy (2004)
3rd History: Stephen Synnott discovers Uranus' moons *Juliet* and *Portia* (1986)
4th Quadrantids meteor shower peaks in the early morning hours; radiates from the constellation Boötes (name from an obsolete constellation called Quadrans Muralis)
4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
5th History: discovery of dwarf planet *Eris* (the Pluto killer) by Mike Brown, et al. (2005)
5th History: President Nixon announces the development of the space shuttle; "a space vehicle that can shuttle repeatedly from Earth to orbit and back" (1972)
5th History: launch of the Soviet atmospheric probe, Venera 5, to Venus (1969)
5th History: discovery of Jupiter's moon *Elara* by Charles Perrine (1905)
6th History: launch of the Lunar Prospector spacecraft; detected signs of water ice in permanently shadowed craters, mapped surface composition and Moon's gravity field and detected outgassing events in the vicinity of craters Aristarchus and Kepler (1998)
6th History: launch of Surveyor 7, the last of the unmanned Surveyor spacecrafts; soft-landed near Tycho crater (1968)
7th History: discovery and first recorded observations of Jupiter's four largest moons *Io*, *Europa*, *Ganymede* and *Callisto* by Galileo Galilei (1610)
8th Scheduled inaugural flight of a United Launch Alliance Vulcan Centaur rocket, carrying the Peregrine commercial lunar lander for Astrobotic and two prototype satellites for Amazon's Kuiper broadband constellation. The launch will be conducted from the Cape Canaveral Space Force Station, Florida
8th Closest approach of Near-Earth Object, Aten class, and Potentially Hazardous Asteroid (2002 AY1)
8th History: launch of Japanese spacecraft Sakigake with mission to rendezvous with Comet *Halley*; measured the solar wind and magnetic field (1985)
8th History: launch of Luna 21 and the Lunokhod 2 moon rover (1973)
8th History: Stephen Hawking born (exactly 300 years after the death of Galileo); discovered that black holes could emit radiation - subsequently known as Hawking radiation (1942)
9th History: Alex Wolszczan and Dale Frail discover two exoplanets (Poltergeist and Phobetor) orbiting a pulsar PSR B1257+12 (1992)
9th History: Voyager 2/Stephen Synnott discovers Uranus' moon *Cressida* (1986)
10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)
10th History: U.S. Army first bounces radio waves off the Moon (1946)
11th New Moon

Astronomical and Historical Events (continued)

11th Closest approach of Near-Earth Object and Aten class asteroid (2020 AC1)
11th History: Lunar Prospector spacecraft enters lunar orbit for a nineteen-month chemical mapping mission (1998)
11th History: William Herschel discovers Uranus' moons *Titania* and *Oberon* (1787)
12th History: launch of the Deep Impact spacecraft for a flyby of comet *Tempel 1*; a small "impactor" was later released from the main spacecraft for a July 4th collision with the comet's nucleus (2005)
12th History: Sergei Pavlovich Korolev born, Chief Designer of the Soviet space program (1907)
12th History: Astronomical Society of London conceived with Sir William Herschel first President (chartered in 1831 as the Royal Astronomical Society) (1820)
13th Second Saturday Stars – Open House at the McCarthy Observatory, 7 PM
13th Moon at perigee (closest distance from Earth)
13th History: Stephen Synnott discovers Uranus' moons *Desdemona*, *Rosalind* and *Belinda* (1986)
13th History: discovery of the Martian meteorite EETA 79001 in Antarctica; second largest Martian meteorite recovered after *Zagami* (1980)
14th History: first of three flybys of the planet Mercury by the Messenger spacecraft (2008)
14th History: landing of the Huygens probe on Saturn's largest moon *Titan* (2005)
15th History: Stardust spacecraft returns samples of Comet P/*Wild 2* (2006)
15th History: launch of the spacecraft Helios 2, solar orbiter (1976)
15th History: Lunokhod 2, the second of two Soviet unmanned lunar rovers, lands in Le Monnier crater; covered a total distance of 23 miles (37 km) in almost five months of exploring the floor of the crater and its southern rim (1973)
16th Closest approach of Near-Earth Object and Aten class asteroid (2021 CZ2)
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th First Quarter Moon
17th Scheduled launch of a SpaceX Crew Dragon from the Kennedy Space Center, Florida. The two-week commercial mission to the International Space Station will be managed by Axiom Space
17th History: Astronomer Edwin Hubble publishes paper that the Universe is expanding – "*A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae*" (1929)
17th History: launch of Jason 3, an ocean altimetry satellite from the Vandenberg Air Force Base, California (2016)
17th History: Pierre Mechain's discovery of Comet 2P/*Encke* (1786); short period comet that completes a circuit around the Sun every 3.3 years, named after Johann Encke who computed the comet's orbit, recognizing it as a periodic comet
19th History: launch of the New Horizons spacecraft to Pluto; executed a close encounter with the dwarf planet in July 2015 (2006)
19th History: Mars Exploration Rover "Opportunity" discovers first meteorite on Mars (Heat Shield Rock) (2005)
19th History: discovery of the Martian meteorite SAU 090, a basaltic shergottite, in Oman (2002)
19th History: discovery of Saturn's moon *Janus* by the Voyager 1 spacecraft (1980)
19th History: launch of Gemini 2, an unmanned suborbital flight designed to test the spacecraft's heat shield (1965)

Astronomical and Historical Events (continued)

19th History: Johann Bode born, popularized an empirical law on planetary distances originally developed by J.D. Titius, known as "Bode's Law" or "Titius-Bode Law" (1747)
20th History: Rich Terrile discovers Uranus' moons *Cordelia* and *Ophelia* (1986)
21st History: launch of the rocket Little Joe-1B and a rhesus monkey named "Miss Sam" in a successful test of the Mercury capsule's escape system (1960)
21st History: John Couch Adams born, astronomer and mathematician who was the first person to predict the position of a planet beyond Uranus (1792)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd Closest approach of Near-Earth Object and Apollo class asteroid (2021 BL3)
23rd History: Brad Smith discovers Uranus' moon *Bianca* (1986)
24th History: launch of space shuttle Discovery (STS-51-C); 100th human spaceflight to achieve orbit (1985)
24th History: discovery of the Martian meteorite Dhofar 019 in Oman (2000)
24th History: launch of Japan's Hiten spacecraft; first use of a low-energy transfer to modify an orbit and the first demonstration of a transfer to the Moon requiring no change in velocity for capture (1990)
24th History: flyby of Uranus by the Voyager 2 spacecraft (1986)
25th Full Moon
25th Closest approach of Near-Earth Object and Apollo class asteroid (2017 BG92)
25th History: exploration rover Opportunity lands on Mars at Meridiani Planum; operated for over 14 years before being crippled by a global dust storm in 2018 (2004)
25th History: launch of the Infrared Astronomical Satellite (IRAS); first space telescope to survey of the entire sky at infrared wavelengths (1983)
25th History: launch of the U.S. Moon orbiter Clementine (1994)
25th History: Joseph Lagrange born (1736); mathematician who discovered five special points in the vicinity of two orbiting masses where a third, smaller mass can orbit at a fixed distance from the larger masses. The L1 Lagrange Point of the Earth-Sun system is the current home of the Solar and Heliospheric Observatory Satellite (SOHO), the James Webb Space Telescope is heading for L2 (1 million miles beyond the Earth and away from the Sun).
26th Closest approach of Near-Earth Object and Aten class asteroid (2011 CQ1)
26th History: discovery of dwarf planet *Haumea*'s moon *Hi'laka* by Mike Brown, et al. (2005)
26th History: discovery of Saturn's moon *Epimetheus* by the Voyager 1 spacecraft (1980)
26th History: launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27th History: fire in the Apollo 1 spacecraft kills astronauts Gus Grissom, Edward White and Roger Chaffee (1967)
27th History: Philibert Melotte discovers Jupiter's moon *Pasiphae* (1908)
28th History: final launch of the space shuttle Challenger (STS-51L); lost on lift-off (1986)
28th History: Johannes Hevelius born; leading observational astronomer of the 17th century, published detailed maps of the Moon and determined the rotational period of the Sun (1611)
29th Moon at apogee (furthest distance from Earth)
29th Scheduled launch of Northrop Grumman's 21st Cygnus cargo freighter aboard a SpaceX Falcon 9 rocket to the International Space Station from the Cape Canaveral Space Force Station, Florida

Astronomical and Historical Events (continued)

29th History: Soviet spacecraft Phobos 2 enter orbit around Mars; successfully returned 38 images before contact was lost; its lander was not deployed (1989)
30th Closest approach of Near-Earth Object and Aten class asteroid (2007 EG)
30th History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st History: launch of SMAP (Soil Moisture Active Passive) satellite into a polar orbit around Earth (2015)
31st History: launch of Apollo 14; third manned moon landing with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell (1971)
31st History: launch of Soviet Moon lander Luna 9; first spacecraft to land and to transmit photographs from the Moon's surface (1966)
31st History: launch of Mercury-Redstone 2 rocket with Ham the chimpanzee (1961)
31st History: launch of the first U.S. satellite, Explorer 1; detected inner radiation belt encircling the Earth (1958)

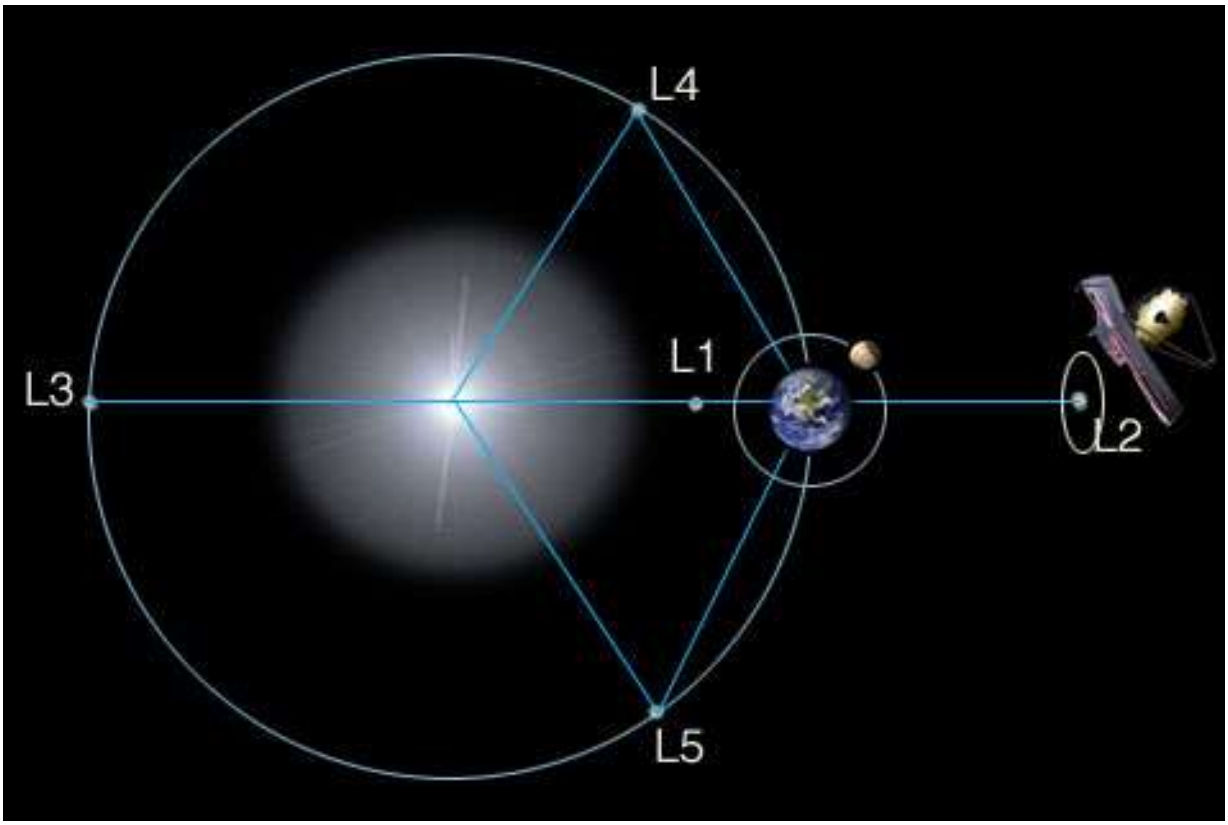
Commonly Used Terms

- 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

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 (location of the Euclide and James Webb telescope) is situated 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

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 the bright flares from Iridium satellites.

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

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 Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/

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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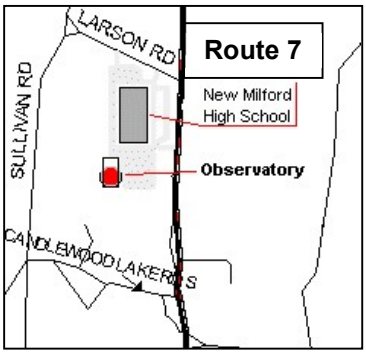

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