Galactic Observer

John J. McCarthy Observatory

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View of Europa from NASA's Juno spacecraft as it executed the first close flyby of the Jovian moon in over twenty years. Credits: Image data: NASA/JPL-Caltech/SwRI/MSSS. Image processing by Björn Jónsson CC BY-NC-SA 2.0)

November Astronomy Calendar and Space Exploration Almanac

Fully Eclipsed Moon
Photo: Bill Cloutier

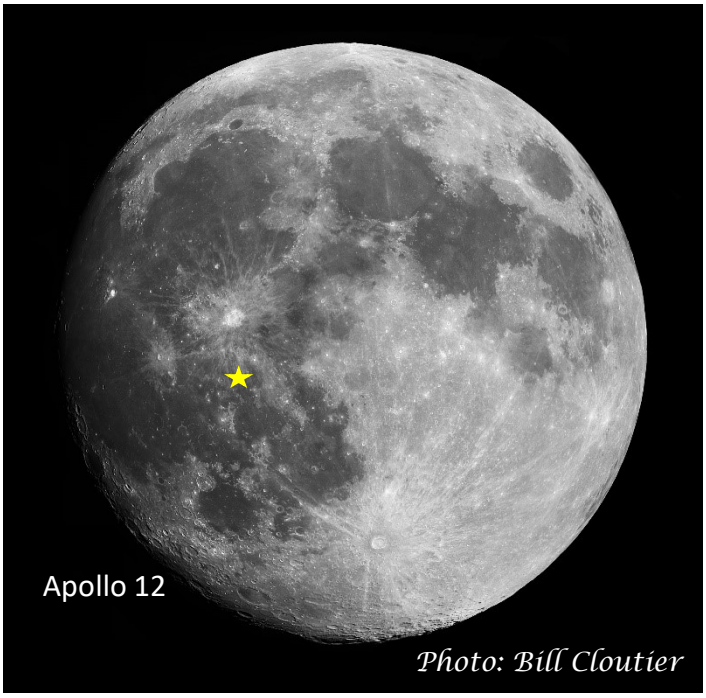
On the morning of November 8th, the Moon will slide into the Earth's shadow for the last Total Lunar Eclipse visible from the east coast of the United States until 2025. Totality begins at 5:16 AM and lasts 86 minutes. Event timing can be found on page 5.

In This Issue

"Out the Window on Your Left"

It's been more than 53 years since Neil Armstrong first stepped onto the Moon's surface and almost 50 years since Gene Cernan left the last footprint. 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).

On a rainy morning in November 1969, despite being struck by lightning (twice) during the first minute of flight, a Saturn V rocket delivered the crew of Apollo 12 into orbit and on its way for the second successful manned Moon landing.



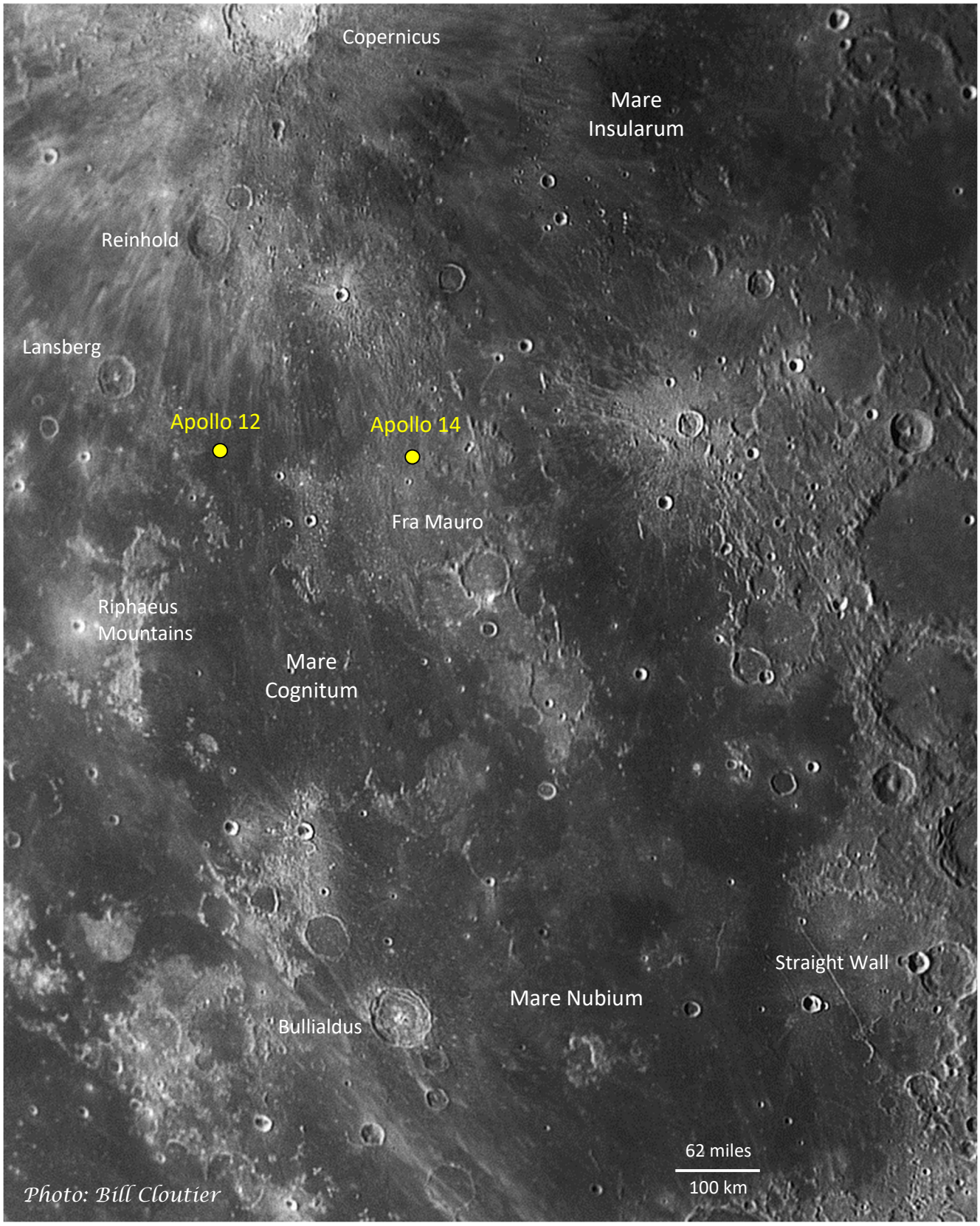
Apollo 12 landed approximately 930 miles (1,500 km) west of the Apollo 11's Tranquility Base. The site was selected for its proximity to Copernicus crater, 250 miles (400 km) to the north, and for the ejecta that was believed to have covered the area from that crater's formation. The location was also home to Surveyor 3, an unmanned robotic spacecraft that landed on the Moon in April 1967.

"Pete" Conrad and Alan Bean executed a pinpoint landing on November 19th, setting down the Lunar Module "Intrepid" 535 feet (163 meters) from the Surveyor spacecraft. To minimize the potential of contaminating the robotic spacecraft by the descent engine exhaust or from dust kicked up by the engine, the landing was required to be at least 500 feet (152 meters) from Surveyor. The Sun was only 6° above the horizon at touchdown, casting long shadows across the volcanic plain and adding sharp relief to the geologic features at the landing site.

The astronauts spent 7 hours and 45 minutes on the surface in two separate excursions, collecting 75 pounds (34 kg) of rock and soil samples, setting up experiments, and removing pieces from Surveyor for further study back on Earth. The most unusual sample collected by the astronauts was a small rock measuring just 2 inches across (5 cm) comprised of potassium (K), rare earth elements (REE), and phosphorus (P). Referred to as KREEP, this material is believed to have formed early in the Moon's history when its magma ocean started to crystalize. An enduring mystery is why KREEP deposits are primarily concentrated on the Moon's nearside.

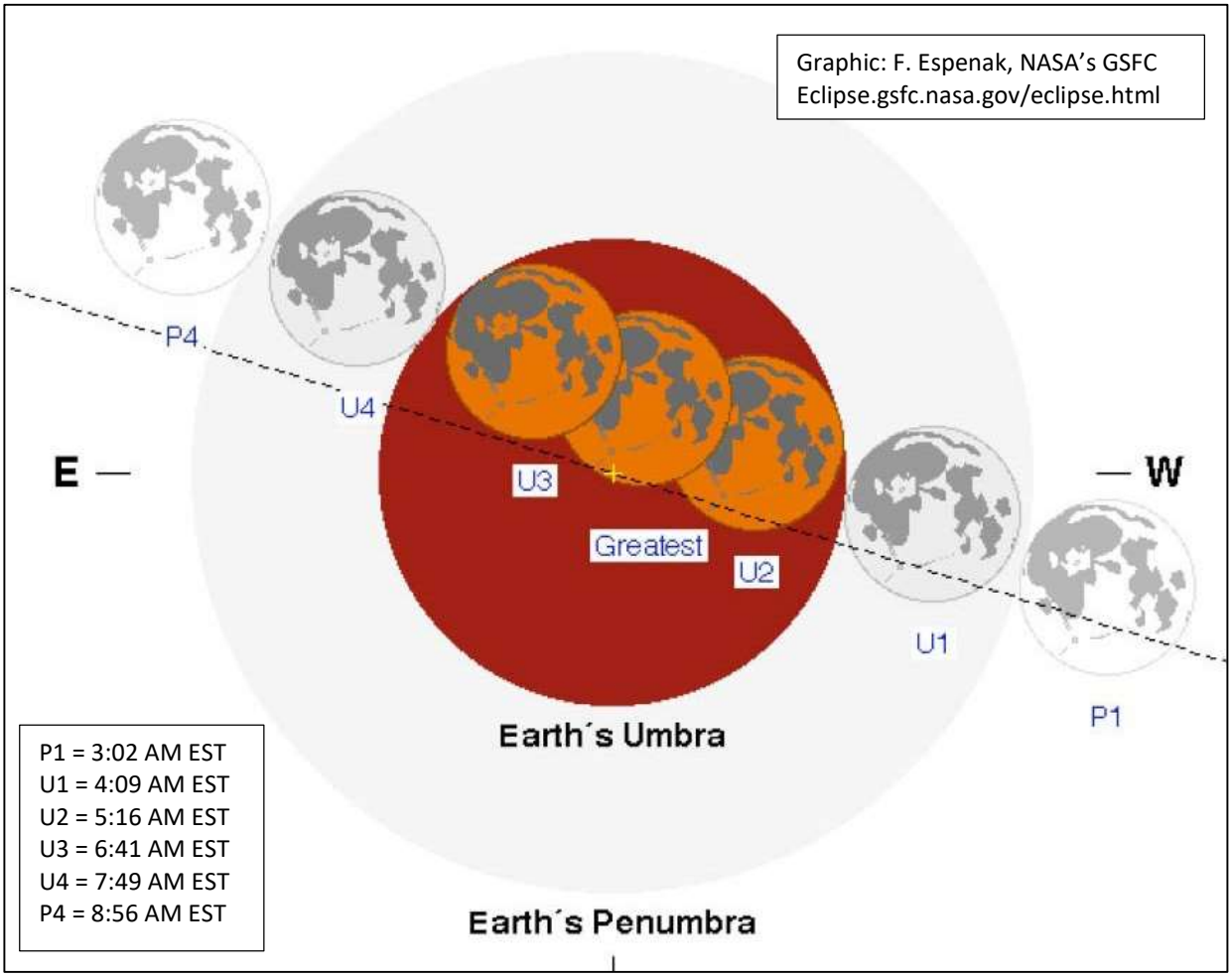
While Conrad and Bean were on the Moon, Command Module Pilot Richard Gordon remained in lunar orbit in the Command Module, the "Yankee Clipper," conducting photographic surveys of potential landing sites. These included the Fra Mauro region, which after the Apollo 13 abort, was redesignated at the target for Apollo 14.

Apollo 12


Copernicus
Mare
Insularum
Reinhold
Lansberg
Apollo 12
Apollo 14
Fra Mauro
Riphaeus
Mountains
Mare
Cognitum
Straight Wall
Mare Nubium
Bullialdus
62 miles
100 km
Photo: Bill Cloutier

Full Beaver Moon Total Lunar Eclipse

In the early morning hours of November 8th, viewers on the east coast will see the Full Beaver Moon slip into the Earth's shadow. Once in the shadow, the Earth will block all direct sunlight from illuminating the lunar surface. This arrangement, with the Earth in line between the Sun and the Moon, produces a lunar eclipse. The image on Page 1 was taken at the McCarthy Observatory on October 27, 2004. It shows the Moon nearing the completion of its travel through the darkest part of the Earth's shadow (or umbra). The crimson glow is from sunlight scattered by the Earth's atmosphere that has filtered out most of the blue colored light. The northern limb of the Moon is brightest as it is closest to the edge of the umbra.

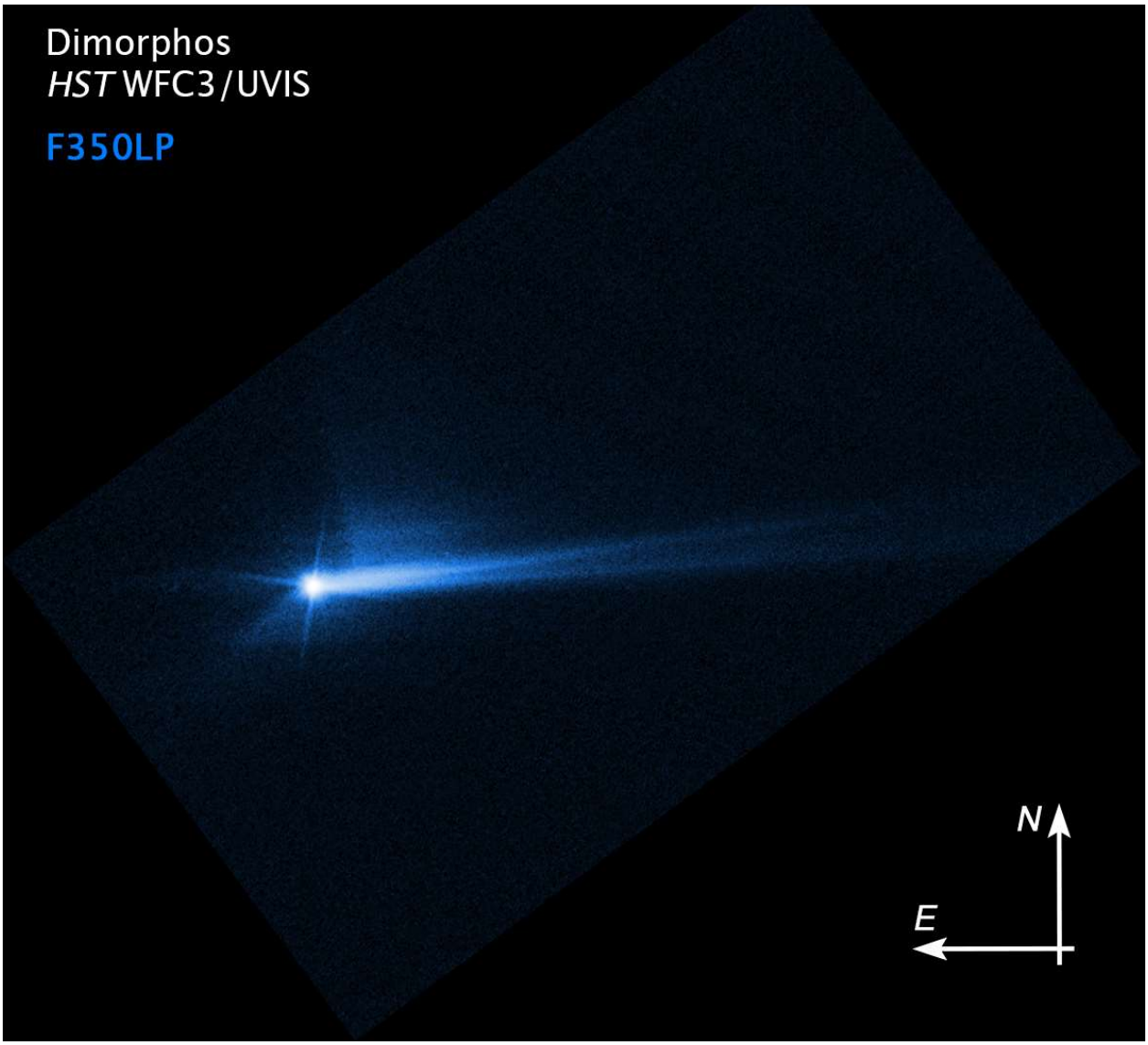


On November 8th, the Moon will once again travel through the northern half of the umbra. The eclipse will be visible from our area (weather permitting) with totality starting at 5:16 AM EST and lasting about 86 minutes. November's Full Beaver Moon will occur just six days before apogee (furthest distance from Earth) and, as a result, will appear slightly smaller than usual.

The Moon will be in the western sky, about 14° above the horizon at the start of totality. The total eclipse phase will conclude as the Moon sets, so a clear view to the horizon and some altitude will maximize your experience. The sky will also be brightening as the eclipse proceeds with Astronomical Twilight ending just before the start of totality and sunrise occurring as its ends.

The next total lunar eclipse will be in March 2025.

A Smashing Success



Looking more like a comet than an asteroid, this image from October 8th was captured by NASA's Hubble Space Telescope and shows the trail of debris blasted from the surface of Dimorphos after it was intentionally impacted by NASA's DART spacecraft on September 26th. The tail is several thousands of miles long. Credits: NASA/ESA/STScI/Hubble

Post-collision analysis of NASA's kinetic impact test indicates that the small moon's orbit was changed by about 4% as a result of the impact with DART, with Dimorphos moving slightly closer to the larger member of the binary pair, Didymos. Observations by multiple observatories in the southern hemisphere and planetary radar facilities in California and West Virginia confirmed that Dimorphos' pre-impact orbital period of 11 hours and 55 minutes was shortened by about 32 minutes to 11 hours and 23 minutes. This is the first time humanity has demonstrated an asteroid deflection technology and successfully altered the trajectory of a celestial object.

In 2026, the European Space Agency's HERA spacecraft will arrive at the binary asteroid to survey the damage inflicted by the DART spacecraft and characterize the two minor planets.

Saturn’s Rings and a Lost Moon

Natural color view of Saturn's rings captured by Cassini’s narrow-angle camera
Credit: NASA/JPL/Space Science Institute

The origin of Saturn’s rings have remained an enigma since they were first observed over 400 years ago. Now, thanks to the data returned by the Cassini spacecraft, which spent 13 years exploring the Saturnian system, the true nature of this glorious disk of icy shards may be within our grasp.

The wildly successful Cassini mission was extended twice from its original four-year primary mission, with the second extension, called the “Cassini Solstice Mission,” lasting until the spacecraft’s destruction in 2017. During Cassini’s final 22 orbits (the “Grand Finale”), the spacecraft passed through the gap between the inner rings and the top of the planet’s atmosphere.

This highly risky maneuver, which entailed using the spacecraft's radio dish as a shield against the ring particles, produced some impressive science: providing a more accurate timing of Saturn's rotation; revealing the mass of the planet's ring system; analyzing the elemental composition of the ring particles; and quantifying the mass-loss rate of the rings from "ring rain."

The mass of the rings, which are almost pure water ice, was determined by measuring the gravitational effect on the spacecraft's trajectory as it moved between the rings and planet. The value was roughly half of many pre-mission estimates or about 41% of the mass of Saturn's seventh largest moon Mimas.

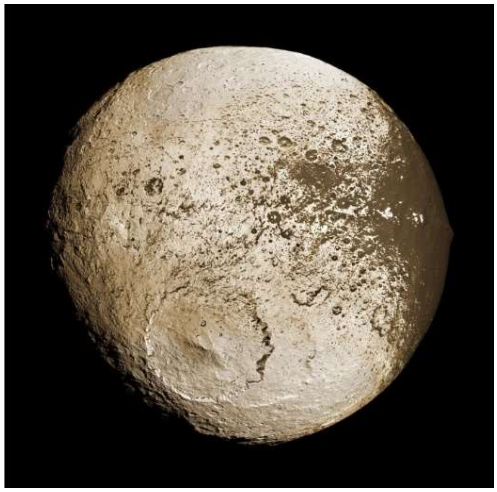
Researchers, using the data collected by Cassini's instruments, have concluded that the rings are a relatively new phenomena (i.e., they did not form with the planet billions of years ago). Recent studies, based on the rate the rings are darkened by meteoroidal material from outside the Saturn system, suggest that the icy wreath is less than 100 million years old, and could be as young as 10 million years.

Cassini was also able to characterize the shower of ring material falling onto the planet (currently at a rate that would fill an Olympic-sized swimming pool every 30 minutes). At this rate, the rings could be depleted in less than 100 million years.

The rings may have also played a role in the planet's current axial tilt or obliquity. Saturn's axis of rotation is tilted about 27° with respect to the plane of its orbit around the Sun, while Jupiter's is only 3°. The tilt is unlikely the result of an impact on a gas giant of this size, so it is probably due to interaction(s) with other bodies in the solar system.

Neptune has a similar orbital tilt and axial period of precession (about 1.87 million years). Researchers had long-suspected a past gravitational relationship between the two worlds but the premise lacked analytical support until Cassini was able to provide a more accurate accounting of the distribution of mass inside Saturn (used in determining the planet's moment of inertia). Based upon the Cassini data, computer modeling and simulations of the bodies in the early solar system suggest that, early-on, Saturn likely became gravitationally locked in a spin-orbit resonance with Neptune. In concert with the migration of Saturn's largest moon Titan, its axis of rotation was tipped over, to as much as 36°, before some event interrupted and then broke the link.

In a study published in the journal *Science*, in September, researchers offered a solution to both Saturn's current tilt and the "recent" manifestation of its rings. The authors propose that the destruction of a hypothetical icy moon (they call "Chrysalis"), about the size of the Saturn's third largest moon Iapetus, changed the planet's moment of inertia, disrupted the gravitational relationship with Neptune, and created the ring system. Continued outward migration of Saturn's largest moon Titan would have then stabilized the system and led to the decrease in the planet's axial tilt to its current value.



Saturn's moon Iapetus
Credit: NASA/JPL-Caltech/Space Science Institute

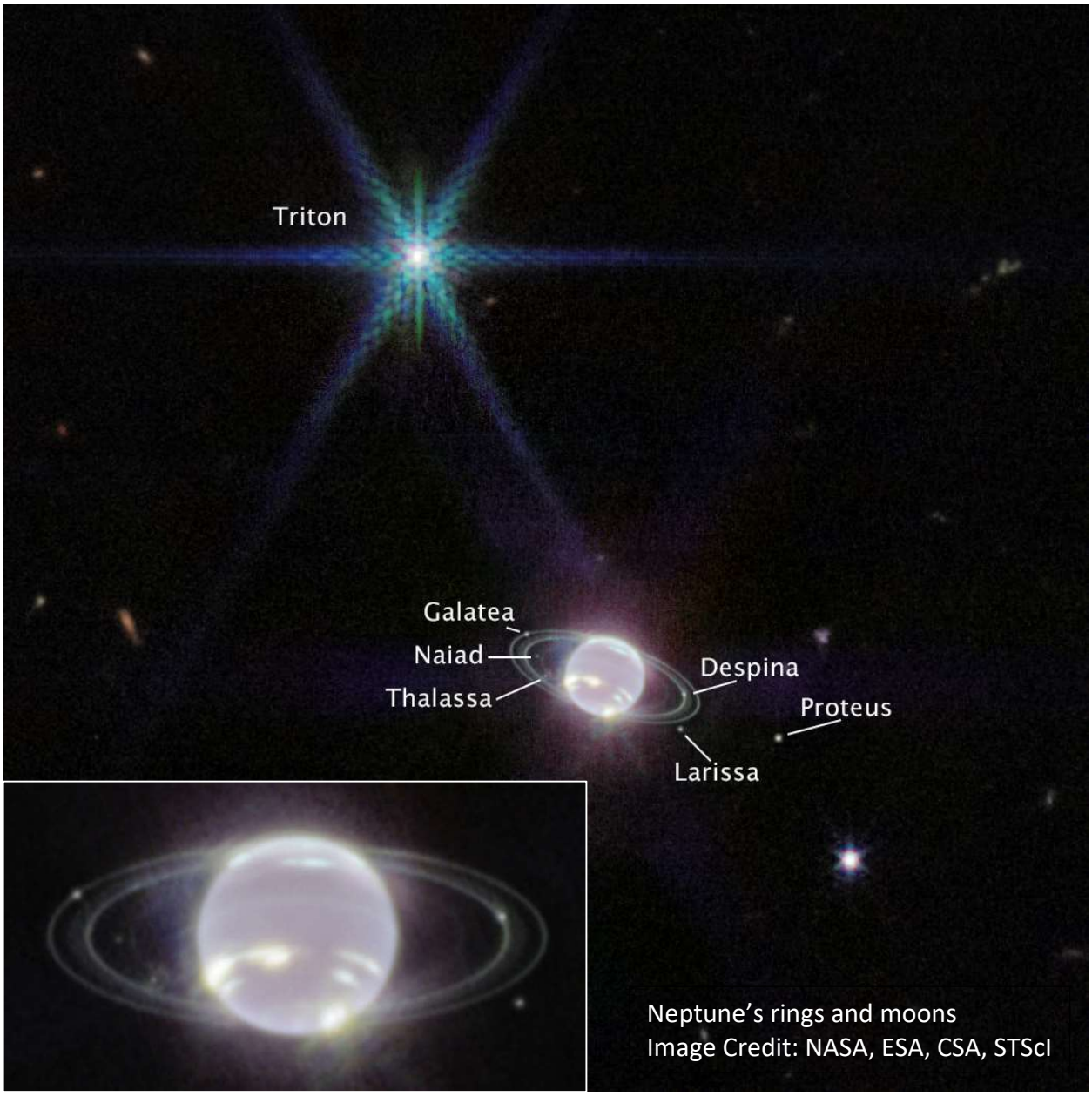
A Visit to an Ocean World

Icy ridges and channels in Europa's icy surface are revealed by Juno's Stellar Reference Unit. Credits: NASA/JPL-Caltech/SwRI

In the early morning of September 29th, NASA's Juno orbiter steaked past Jupiter's moon Europa at a velocity in excess of 52,000 mph (23.6 km per second), coming as close to the icy surface as 219 miles (352 km). The flyby provided the closest views of the enigmatic moon since a Galileo orbiter pass in 2000.

Juno has been orbiting Jupiter since 2016, but a change in its trajectory during the extended phase of its mission set up the encounter with Europa. The image (above) covers an area of 93 by 125 miles (150 km by 200 km) and was taken on the moon's nightside. It was captured by the spacecraft's star-tracker camera typically used for navigation. Illumination for the image was provided by sunlight reflecting off Jupiter's cloud tops. The moon's frozen surface is believed to conceal a salty ocean containing more water than Earth's oceans. Juno's images are being studied and analyzed as NASA prepares its Europa Clipper astrobiology mission for launch in 2024.

Neptune's Rings Shine in the Infrared



On September 21st, the James Webb Space Telescope, which has delivered stunning views of the universe's most distant galaxies and stars, trained its Near-Infrared Camera (NIRCam) on a target closer to home. These are the first infrared images of Neptune's rings since they were detected in 1989 during a Voyager 2 flyby.

In the image (above), Webb also captured seven of Neptune's 14 known moons. In the upper left, and highlighted by the telescope's distinctive diffraction spikes (created by the primary mirror's shape and secondary mirror's supports), is Neptune's largest moon - Triton. Covered in a shroud of frozen nitrogen, the moon is not only highly reflective, but geologically active with icy plumes that hint of a subsurface ocean. Triton's orbit is retrograde (backwards, compared to the planet's rotation), suggesting that the moon did not form locally, but was gravitationally captured by the ice giant during a close encounter and may have originally come from the Kuiper belt.

Icons of Science Fiction at the National Air and Space Museum

Believing that exploration and adventure begins with inspiration and imagination, the National Air and Space Museum is including two iconic spacecraft from the annals of science fiction in their newly renovated space-themed galleries inside the west wing of its building in Washington, DC. The latest addition is a full-sized T-70 X-wing Starfighter from the Star Wars movies. On long-term loan from Lucasfilm, the fighter will be on display outside the planetarium after spending some time in the refurbishment hanger at the Museum's Steven F. Udvar-Hazy Center.

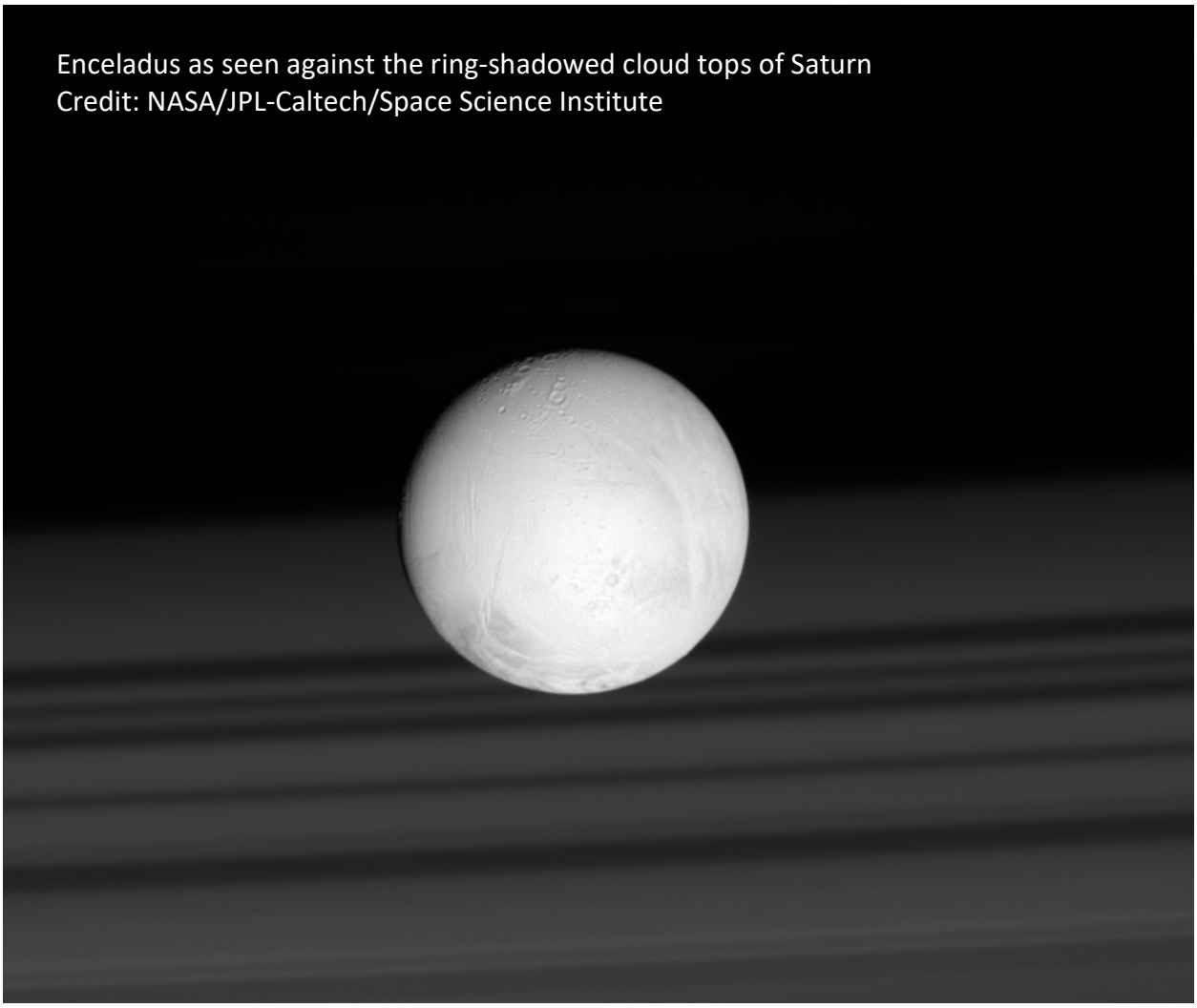
X-Wing Starfighter
Source: Smithsonian's National Air and Space Museum,
Photographer: Jim Preston

USS Enterprise
Source: Smithsonian's National Air and Space Museum

The Star Wars prop will join the 11-foot-long studio model of the starship USS Enterprise used in 79 episodes of the original Star Trek 1960's television series. The starship's design was based on parameters of the series creator, Gene Roddenberry. The model, first used in 1966, required extensive restoration before being readied for display.

Enceladus and Phosphorus

While Jupiter's moon Europa is the target of NASA's next astrobiology mission, the case for a return to Saturn's moon Enceladus continues to gain support among the scientific community. It wasn't long after Cassini entered orbit around Saturn that the small icy moon peaked the interests of project scientists with the discovery of active plumes erupting from its south pole. Multiple flybys, including a deep drive though the plumes in October 2015, provided convincing evidence of a subsurface, global ocean. Signs of oceanic hydrothermal activity and a favorable brew of chemicals detected within the plumes added support for habitability.

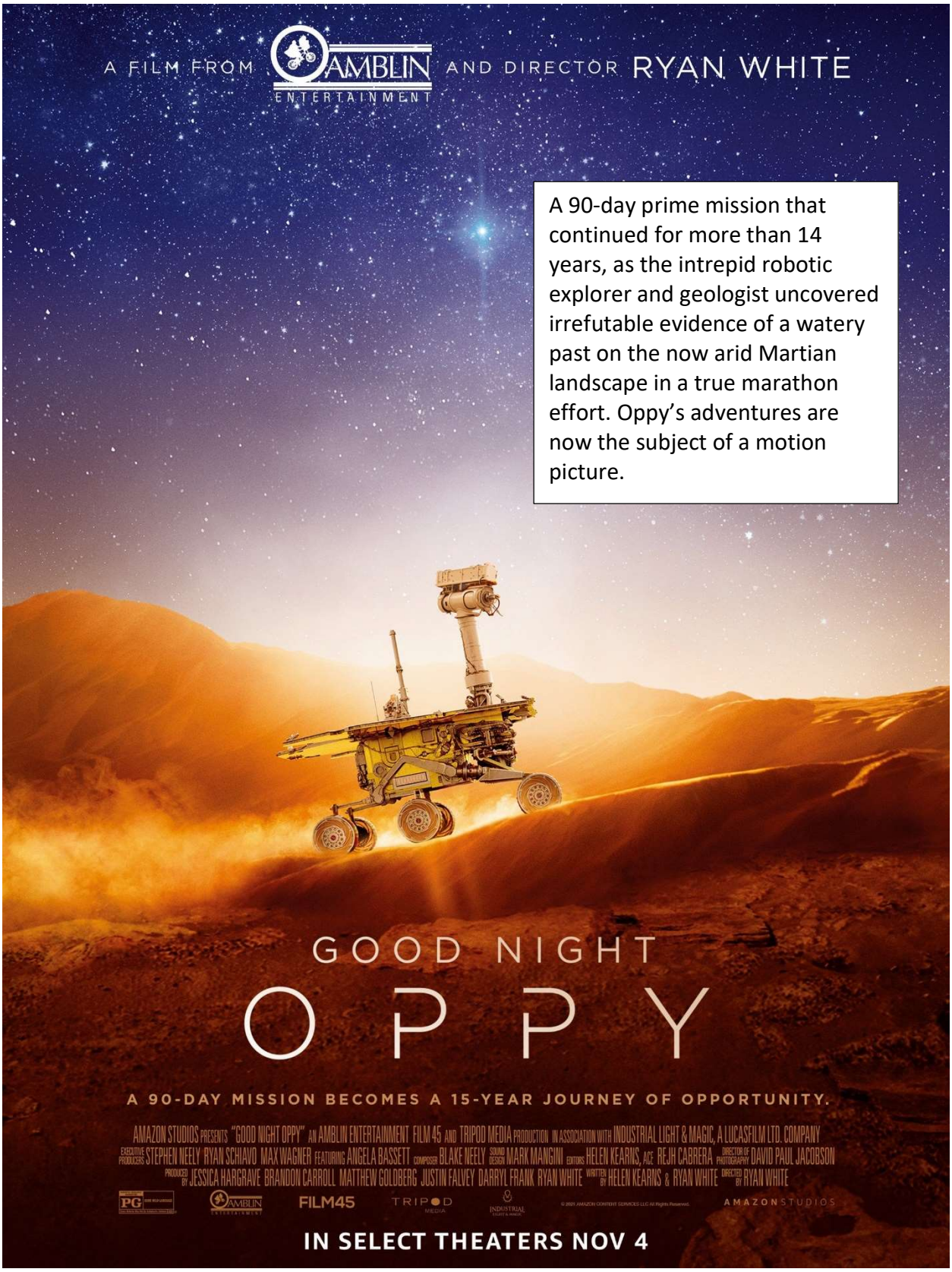


Enceladus as seen against the ring-shadowed cloud tops of Saturn
Credit: NASA/JPL-Caltech/Space Science Institute

The case for life in Enceladus' ocean is further strengthened by a recent analysis by the Southwest Research Institute indicating that phosphorus, in the form of orthophosphate, is likely abundant in the moon's ocean. Phosphorus is an essential ingredient for life (at least on Earth) and for the creation of DNA and RNA.

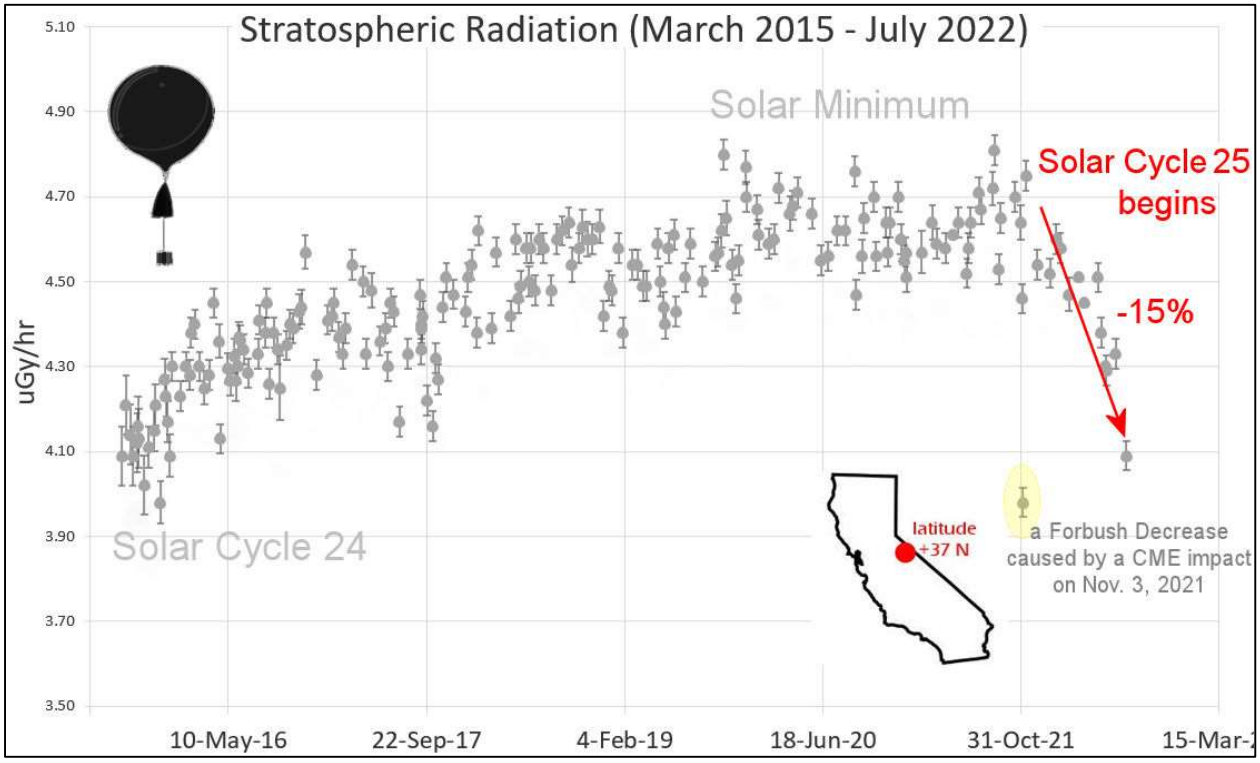
Liquid water, a source of energy, the presence of organic compounds, and the right chemistry, warrant funding of a life-finding probe to this diminutive world. With a more radiation-benign environment than Europa, a lander on Enceladus could conduct an extensive surveys of the moon's south polar region and, with mobility, explore active vents and sample subsurface material without having to drill though the icy shell.

Mars Exploration Rover "Opportunity" Gets Star Treatment

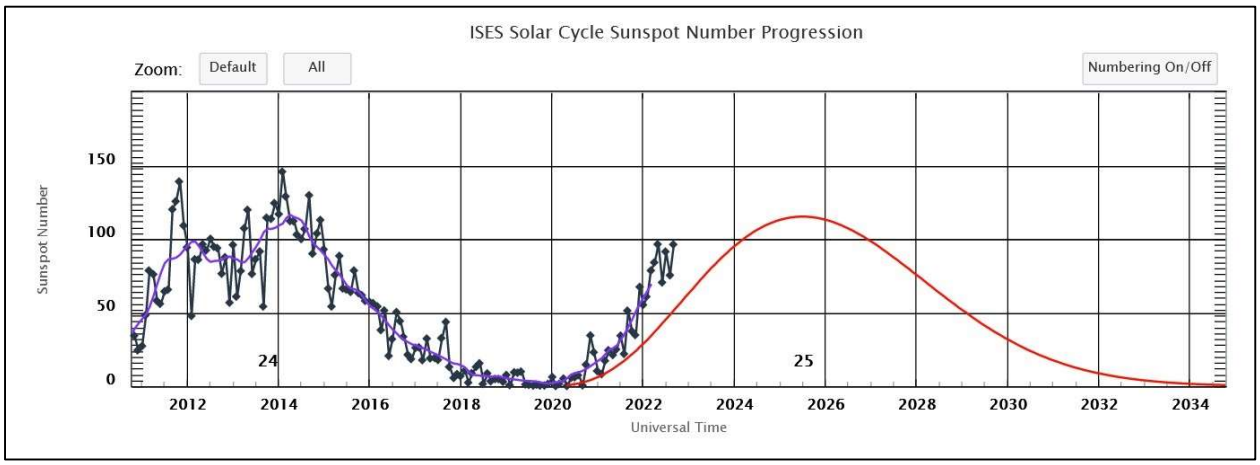


Solar Cycle 25

A new eleven-year solar cycle, triggered when the Sun's magnetic fields completely flips, is underway, and progressing ahead of predictions. Cycle activity is indicated by changes in the activity on the Sun's surface (photosphere), such as sunspots, and the growing strength of the Sun's magnetic field, which deflects incoming cosmic rays from galactic sources.

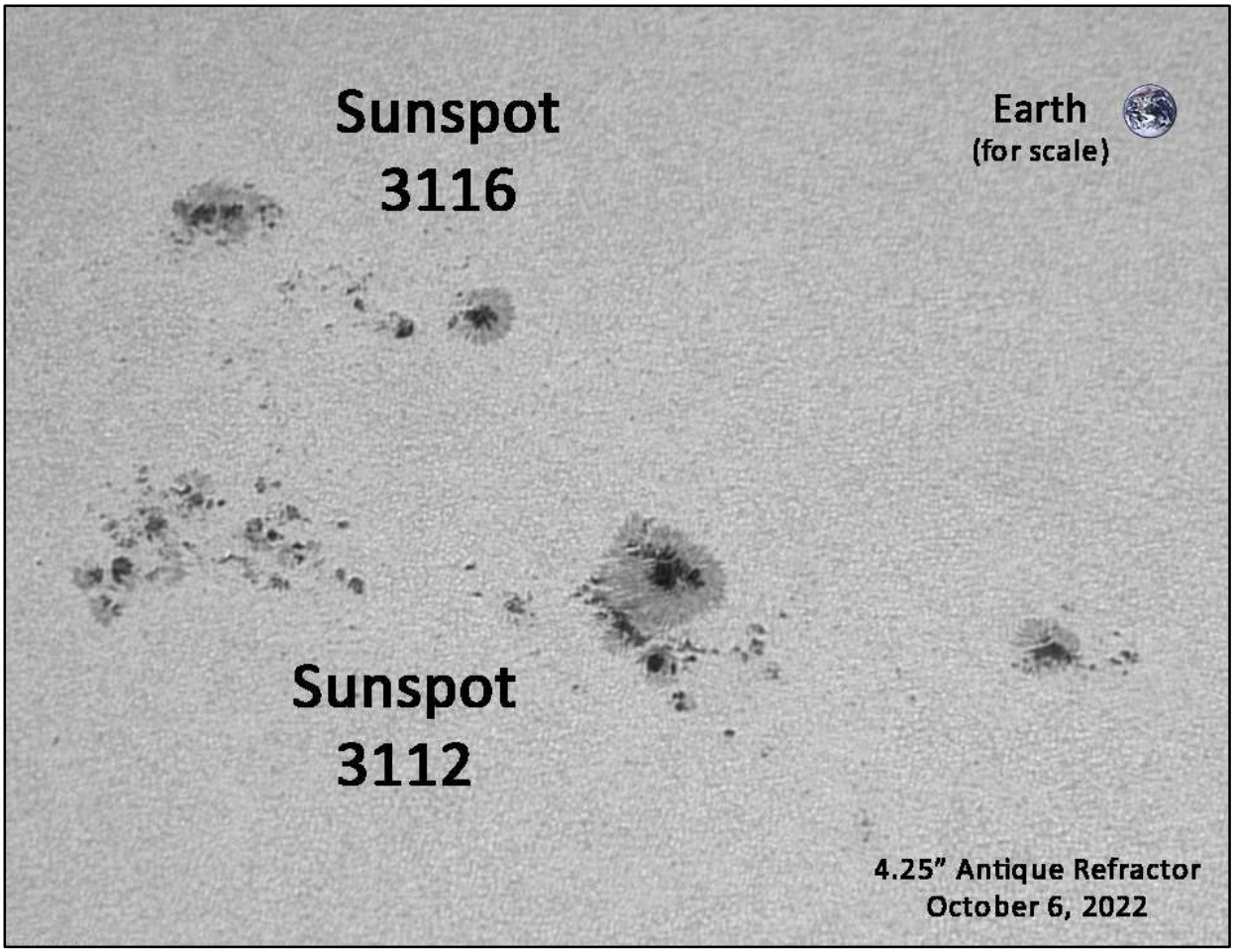


Decline in cosmic radiation over California correlates with the reawakening of solar activity
Credit: Spaceweather.com and the students of Earth to Sky Calculus



Sunspot counts over time. Initial predictions were for a relatively weak Solar Cycle 25, peaking in mid-2025. To date, higher than expected sunspot numbers suggested a stronger cycle and an earlier peak (late 2024).
Credit: NOAA/NASA

Monster Sunspots



Solar Cycle 25 has produced some monster sunspots, but, so far, none of the most energetic outbursts have been Earth-directed. Sunspots appear where the magnetic field is particularly strong. Field lines near the sunspots often tangle, cross and reorganize, producing powerful releases of energy in the form of solar flares and coronal mass ejections.

These outbursts, if Earth-directed, can cause communication blackouts, damage orbiting spacecraft and overload transmission networks on Earth.

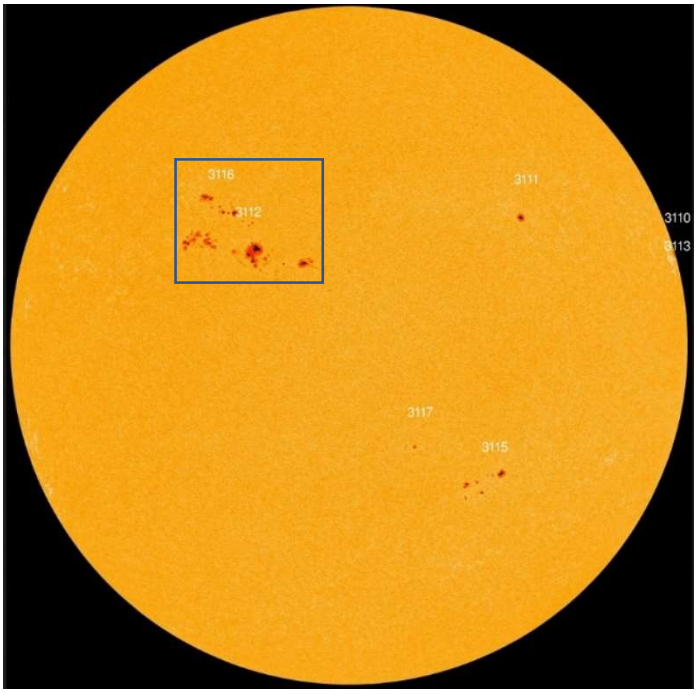
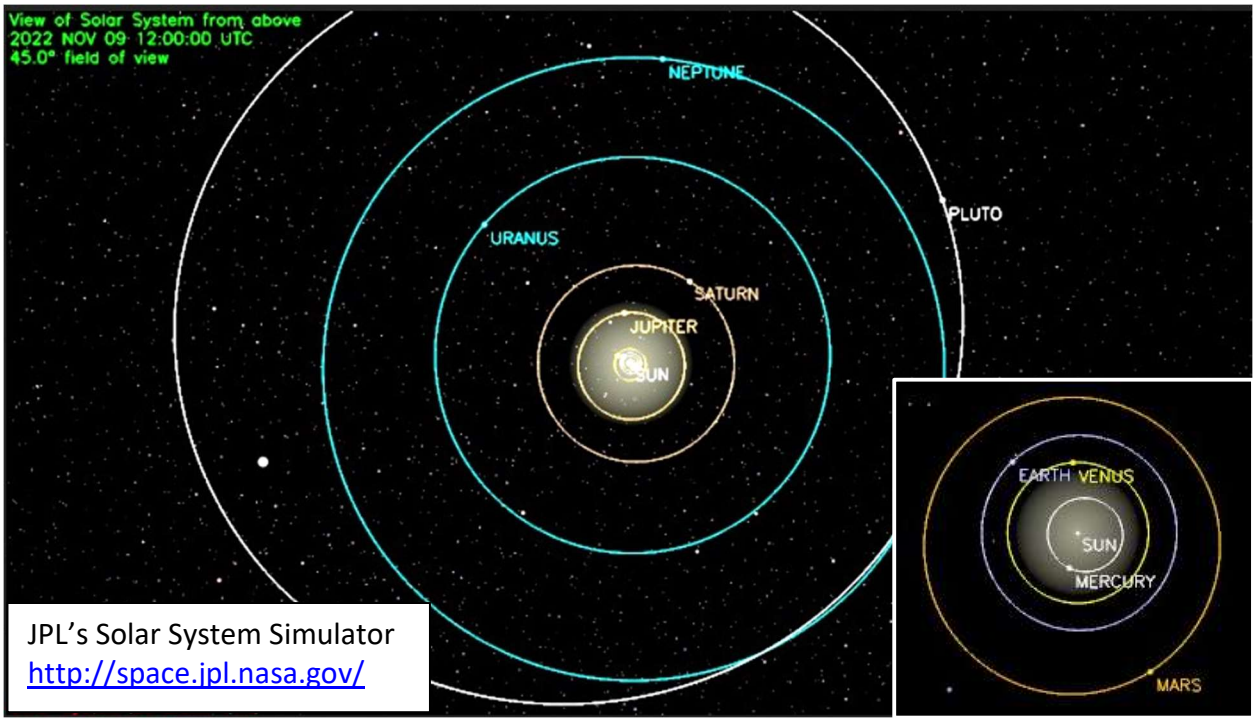


Image from the Helioseismic Magnetic Imager (HMI) aboard the Solar Dynamics Observatory showing the location of the sunspot complex

Uranus at Opposition



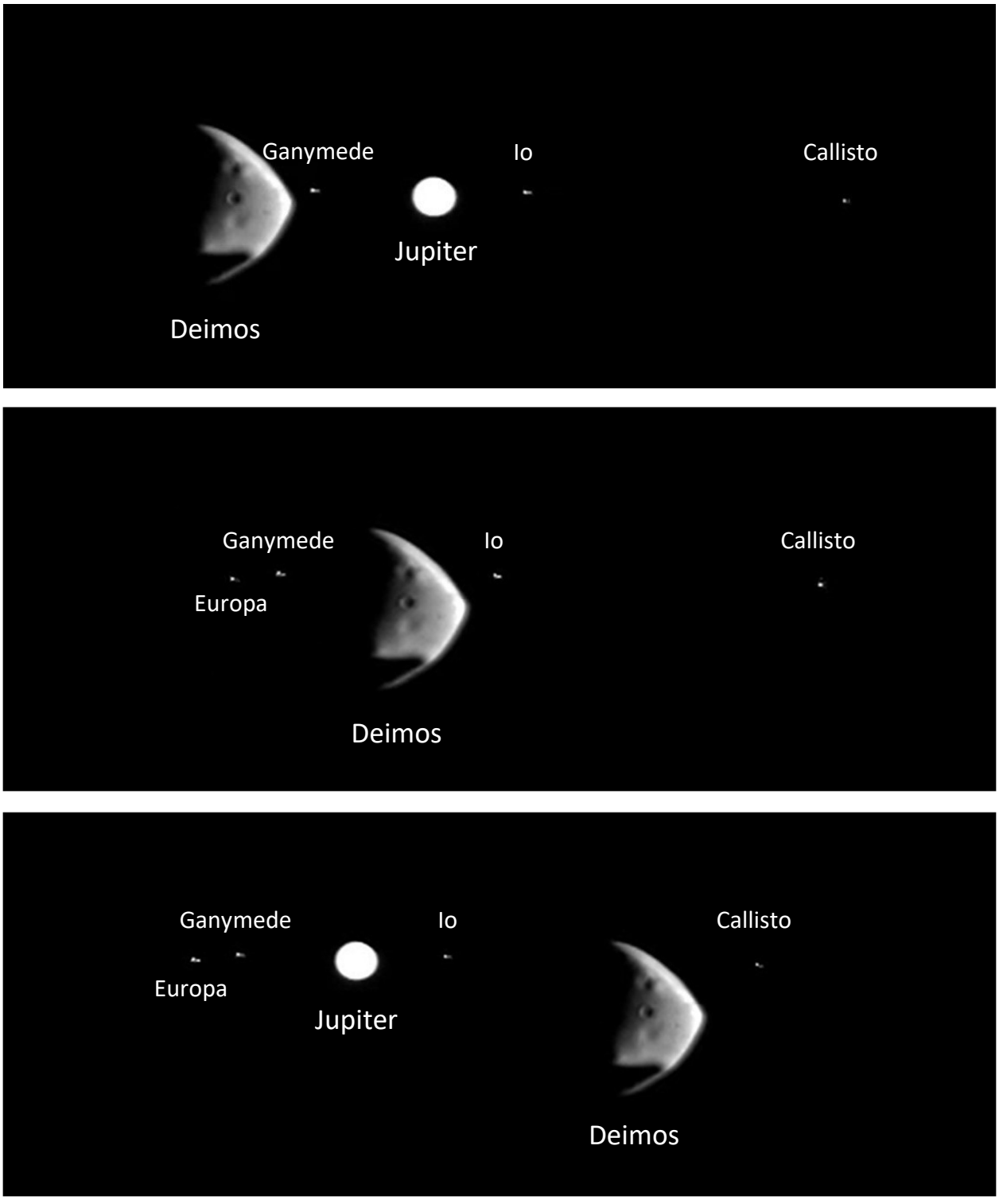
The Earth will come between Uranus and the Sun on November 9th (EST), i.e., "Opposition." On that day, Uranus will rise as the Sun sets and will be visible throughout the night (highest in the southern sky after midnight). At magnitude 5.7, it can be spotted by keen eyes in the constellation Aries, near the head of the sea monster Cetus under ideal sky conditions. Uranus will be approximately 1.75 billion miles (2.8 billion km) from Earth at Opposition.

William Herschel is credited with the discovery of Uranus in 1781 with his home-made telescope, although the planet had been observed, and recorded as a star by many observers including; Hipparchus in the 2nd century BC, the English astronomer John Flamsteed in 1690, and the French astronomer Pierre Le Monnier in the 1750s. Uranus was named for the Greek god of the sky, notwithstanding Herschel's preference to name the planet after his benefactor, King George III (Georgium Sidus).

Uranus is an ice giant and seventh planet from the Sun. The third largest planet in diameter, Uranus' spin axis is tilted more than 90° (the planet basically spins on its side). The tilt is likely the result of a collision with another planetoid billions of years ago. Thirteen faint rings surround the planet along with 27 small moons. A day on Uranus lasts about 17 earth-hours and it takes 84 earth-years to complete a single orbit around the Sun. Winters last 21 years with one half of the planet sunlit and the other in total darkness.

Methane in the atmosphere of Uranus gives the planet its blue-green color. Hydrogen, helium, water and ammonia are the other constituents of a slushy atmosphere that surrounds a rocky core. The planet is believed to have formed closer to the Sun before migrating out to its current position. Few details were visible when visited by the Voyager 2 spacecraft in 1986, however, more recent observations from the Hubble Space Telescope and other Earth-bound observatories have detected dark clouds and storms with bright cloud tops in Uranus' atmosphere.

A Fortuitous Vantage Point



Selected frames from 80 images captured by the High-Resolution Stereo Camera onboard the Mars Express orbiter, showing the Martian moon Deimos moving in front of Jupiter and the Galilean moons. Jupiter was 464 million miles (745 million km) from Mars at the time. Copyright ESA/DLR/FU Berlin – CC BY-SA 3.0 IGO, K.-D. Matz

Artemis I Update

After two launch aborts due to hydrogen fueling leaks, NASA's new Moon rocket was moved back into the Vehicle Assembly Building as Hurricane Ian approached as a precaution and for general maintenance (including the replacement of the Flight Termination batteries). NASA is planning to roll the rocket back out to the pad 39B on November 4th for a tentative launch attempt just after midnight on the 14th. Credit: NASA/Glenn Benson

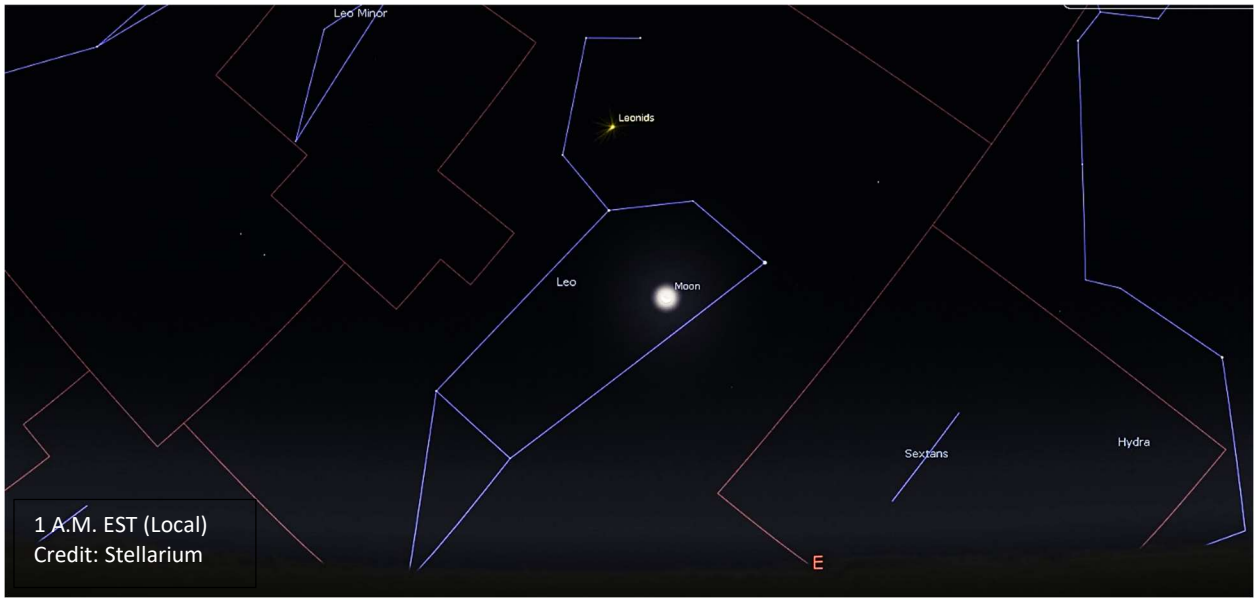
Leonid Meteor Shower

Almost everyone has seen a 'shooting star;' but not everyone knows what they are, where they come from and how best to view them. For those of you that remember that chilly November night in 2001 when the stars fell like rain, a meteor shower or meteor storm is truly unforgettable. As with that night, all you need are a comfortable chair and a warm blanket to enjoy the show.

Meteor showers occur when the Earth passes through a cloud of debris left behind by a comet. As a comet nears the Sun, the volatile gases warm and erupt along with trapped particles of rock and dust. Pushed away from the comet by the solar wind, this material forms the comet's tail. Each time a comet crosses the Earth's orbit it leaves behind a small cloud of debris. When the Earth passes through these clouds, the debris quickly heats up in the atmosphere, creating streaks of light across the night sky. The point in the sky where the meteors appear to originate is called the radiant. Meteor showers are identified by the constellation in which the radiant appears. As such, if you trace the path of the meteors in the early morning of November 17th, you will notice that most seem to originate from a point in the constellation Leo, hence the name Leonids.

Why does the same meteor shower excite one year and disappoint the next? While comets are responsible for seeding Earth's orbit with the makings of a meteor shower, most comets are not frequent visitors to the inner solar system. Comet Tempel-Tuttle (the source of the Leonid meteors) crosses Earth's orbit once every 33 years. The resulting cloud is about 10 Earth diameters across and continues to drift along the comet's path. Most years the Earth misses these clouds altogether. In those years the meteor shower is sparse. Other years, as in 2001, the Earth can interact with several clouds of debris from Comet Tempel-Tuttle. If the debris fields are dense (containing a lot of rock and dust) the show can be spectacular. However, as debris clouds age they stretch out and become less dense. The resulting encounter produces fewer and fewer meteors.

What can we expect this year? Typically, the shower produces an average of 15-20 meteors per hour during the peak period from a dark site (as long as the skies are clear). This year, the shower peak happens around the third quarter Moon. Rising around midnight and also in the constellation Leo, the Moon's proximity to the radiant may wash out many of the weaker meteors.



Saturn

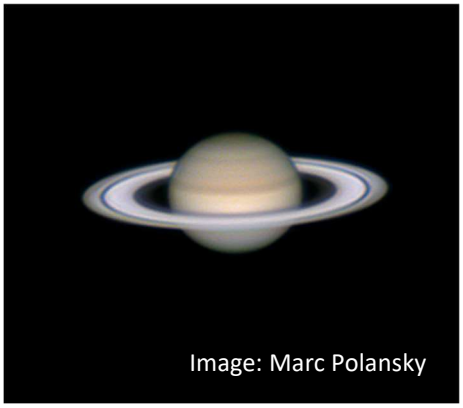


Image: Marc Polansky

Saturn reached Opposition in mid-August when the ringed-world was closest to Earth. Since that time, the distance between the Earth and Saturn has been steadily increasing with Earth's higher orbital velocity. Saturn is still well placed in the evening sky in the constellation Capricornus. The planet's north pole is currently tilted towards the Earth with its rings inclined at an angle of almost 14° to our line of sight. We see the ring tilt or inclination cycle (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


Image: Marc Polansky

Jupiter reached Opposition in late September. The gas giant still shines brightly in the eastern sky after sunset (about 24 times brighter than Saturn). The largest planet in the solar system can be found in the constellation Pisces to the east of Saturn.

	Rise and Meridian Transit Times			
	November 1 (EDT)		November 30 (EST)	
Planet	Rise	Transit*	Rise	Transit*
Saturn	2:33 pm	7:35 pm	11:42 pm	4:45 pm
Jupiter	4:13 pm	10:09 pm	1:16 pm	7:12 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. 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	8:30 pm	10:43 pm
2nd	Europa	6:30 pm	9:00 pm
2nd	Ganymede	8:22 pm	11:08 pm
8th	Io	9:25 pm	11:38 pm
9th	Europa	8:06 pm	10:35 pm
16th	Europa	10:42 pm	1:11 am (17th)
17th	Io	5:50 pm	8:03 pm
24th	Io	7:46 pm	9:59 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 8 pm to midnight local time.

Date	Transit Time	Date	Transit Time
1st	8:32 pm	17th	10:44 pm
3rd	10:10 pm	20th	8:14 pm
5th	11:48 pm	22nd	9:52 pm
8th	8:18 pm	24th	11:31 pm
10th	9:57 pm	25th	7:22 pm
13th	7:26 pm	27th	9:01 pm
15th	9:05 pm	29th	10:40 pm

November Nights

The late Harvard University astronomer Harlow Shapley was born in November 1885. One of his many accomplishments was accurately measuring the distance to globular star clusters and their position around the Milky Way Galaxy. While warm summer nights are usually reserved for hunting globulars, the autumnal sky contains several impressive clusters including M15 in Pegasus and M2 in Aquarius. M30 in Capricorn is also visible in the southwest sky in the evening.

On the eastern side of the Great Square of Pegasus is the constellation Andromeda. Within this constellation and visible to the unaided eye on a dark night is the Andromeda Galaxy (M31), a massive pinwheel of 500 billion suns. Larger than the Milky Way, the Andromeda Galaxy is currently rushing towards us at 75 miles per second. Fortunately, it is approximately 2½ million light years (14.7 million trillion miles) distant, so it will be some time before the two galaxies merge. Visible through a telescope are Andromeda's two companion galaxies, M32 and M110. While M32 can be mistaken for a bright star due to its close proximity to the core of the Andromeda Galaxy, M110 is a bit easier, being further away and larger than M32.

Located not far from M31 is the Triangulum or Pinwheel Galaxy (M33). Smaller and less massive than the Milky Way, this galaxy can be a challenge to see on less-than-ideal nights, due to its low surface brightness. However, through a large telescope on a dark, steady night, the view looking face-on at this giant pinwheel can be spectacular. The large spiral arms of M33 are filled with star-forming regions that almost appear to be gliding through space.

Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
November 1st (EDT)	07:25	17:48
November 15th (EST)	06:42	16:33
November 30th	06:59	16:24

Astronomical and Historical Events

1st First Quarter Moon
1st Aten Asteroid *2021 VH* near-Earth flyby (0.015 AU)
1st History: launch of the Wind spacecraft, designed to monitor the solar wind (1994)
1st History: opening of the Arecibo Observatory (radio telescope) in Arecibo, Puerto Rico (1963)
2nd Kuiper Belt Object 55636 (*2002 TX300*) at Opposition (42.185 AU)
2nd History: flyby of Asteroid *5535 Annefrank* by the Stardust spacecraft (2002)
2nd History: first light at the 100-inch telescope on Mount Wilson (1917)
3rd Taurids Meteor Shower peak (associated with the comet *Encke*)
3rd Kuiper Belt Object 42301 (2001 UR163) at Opposition (52.971 AU)
3rd History: launch of Mariner 10 to Venus and Mercury; first mission to use the gravitational pull of one planet (Venus) to reach another (Mercury) (1973)
3rd History: launch of Sputnik 2 and a dog named Laika (1957)
4th History: Deep Impact's closest approach to the nucleus of Comet 103P/Hartley 2 (2010)
4th History: launch of the Soviet Venus lander Venera 14 (1981)
5th Atira Asteroid 164294 (*2004 XZ130*) closest approach to Earth (0.472 AU)
5th Apollo Asteroid *4183 Cuno* closest approach to Earth (1.483 AU)
5th Kuiper Belt Object *15760 Albion* (1992 QB1) at Opposition (40.534 AU)
5th History: Parker Solar Probe's first close encounter with the Sun's corona (0.17 AU) (2018)
5th History: launch of India's Mars Orbiter Mission (MOM) from the Satish Dhawan Space Centre (2013)
5th History: Chinese spacecraft Chang'e 1 enters orbit around Moon (2007)
6th Scheduled launch of a Cygnus cargo freighter to the International Space Station from Wallops Island, Virginia, aboard an Antares rocket
6th End of Daylight Saving Time - set clocks back one hour at 2 A.M.
6th Apollo Asteroid *5731 Zeus* closest approach to Earth (1.075 AU)
6th History: launch of Lunar Orbiter 2, Apollo landing site survey mission (1966)
7th Apollo Asteroid *6239 Minos* closest approach to Earth (1.604 AU)
7th History: launch of Mars Global Surveyor (1996)
7th History: launch of Surveyor 6 moon lander (landed two days later)
7th History: French astronomer Pierre Gassendi first to observe a transit of the planet Mercury across the Sun's disk (1631)

Astronomical and Historical Events (continued)

7th History: a 300-pound stony meteorite falls in a wheat field outside the walled town of Ensisheim in Alsace (now part of France) (1492)
8th Full Moon (Beaver Moon)
8th Total Lunar Eclipse (see page 5)
8th Apollo Asteroid *2020 WD* near-Earth flyby (0.008 AU)
8th Atira Asteroid *2017 XA1* closest approach to Earth (0.839 AU)
8th Kuiper Belt Object *2014 UZ224* at Opposition (87.946 AU)
8th History: launch of the ill-fated Phobos-Grunt spacecraft from the Baikonur Cosmodrome in Kazakhstan. Destined for the Martian moon Phobos, the spacecraft never left Earth orbit and eventually re-entered the atmosphere. (2011)
8th History: meteorite hits a house in Wethersfield, Connecticut (1982)
8th History: launch of Pioneer 9 into solar orbit (1968)
8th History: launch of Little Joe rocket, qualifying flight for the Mercury spacecraft (1960)
8th History: Edmund Halley born, English astronomer who calculated the orbit and predicted the return of the comet now called Comet Halley (1656)
9th Uranus at Opposition
9th Scheduled launch of the Joint Polar Satellite System 2, polar-orbiting weather satellite for NASA and NOAA and the Low-Earth Orbit Flight Test of an Inflatable Decelerator from the Vandenberg Space Force Base, California aboard an Atlas 5 rocket
9th Amor Asteroid *3288 Seleucus* closest approach to Earth (2.074 AU)
9th Kuiper Belt Object 472271 (*2014 UM33*) at Opposition (42.131 AU)
9th Kuiper Belt Object *2014 US277* at Opposition (76.780 AU
9th History: launch of the Venus Express spacecraft; ESA Venus orbiter (2005)
9th History: launch of OFO-1 (Orbiting Frog Otolith) - two bullfrogs launched in an experiment to monitor the adaptability of the inner ear to sustained weightlessness (1970)
9th History: launch of the first Saturn V rocket, Apollo 4 (1967)
10th Apollo Asteroid *2019 XS* near-Earth flyby (0.043 AU)
10th Kuiper Belt Object *2014 HP233* at Opposition (36.001 AU)
10th History: launch of Luna 17, Soviet Moon rover mission (1970)
10th History: launch of USSR spacecraft Zond 6; Moon orbit and return (1968)
10th History: Waseda Meteorite Fall; hits house in Japan (1823)
11th History: launch of Gemini 12 with astronauts James Lovell and Edwin Aldrin (1966)
11th History: Tycho Brahe discovers a new star in the constellation Cassiopeia shining as bright as Jupiter; later determined to be a supernova - SN1572 (1572)
12th Second Saturday Stars – Open House at the McCarthy Observatory (7:00 pm)
12th Kuiper Belt Object 120348 (*2004 TY364*) at Opposition (37.797 AU)
12th Plutino 144897 (*2004 UX10*) at Opposition (38.484 AU)
12th Kuiper Belt Object 84522 (*2002 TC302*) at Opposition (42.549 AU)
12th History: Philae lander (Rosetta mission) touches down on Comet 67P/*Churyumov-Gerasimenko* (2014)
12th History: launch of STS-2, second flight of the Space Shuttle Columbia (1981)
12th History: flyby of Saturn by the Voyager 1 spacecraft (1980)
12th History: Seth Nicholson born, American astronomer who discovered four of Jupiter's moons, a Trojan asteroid, and computed orbits of several comets and of Pluto (1891)
13th Apollo Asteroid *4450 Pan* closest approach to Earth (1.269 AU)
13th Atira Asteroid *2012 VE46* closest approach to Earth (1.312 AU)

Astronomical and Historical Events (continued)

13th Amor Asteroid *4055 Magellan* closest approach to Earth (1.944 AU)
13th Centaur Object *2015 JH1* at Opposition (12.442 AU)
13th Plutino *47171 Lempo* (2 moons) at Opposition (29.846 AU)
13th Kuiper Belt Object 55637 (*2002 UX25*) at Opposition (38.973 AU)
13th History: launch of HEAO-2, the second of NASA's three High Energy Astrophysical Observatories; renamed Einstein after launch, it was the first fully imaging X-ray space telescope (1978)
14th Moon at apogee (furthest distance from Earth)
14th Scheduled launch of Artemis 1, an unmanned Moon mission, from the Kennedy Space Center aboard NASA's Space Launch System
14th Kuiper Belt Object *2014 ST373* at Opposition (50.528 AU)
14th History: dedication of the New Milford Solar System Scale Model (2009)
14th History: Mariner 9 arrives at Mars; first spacecraft to orbit another planet (1971)
14th History: launch of Apollo 12, with astronauts Pete Conrad, Richard Gordon and Alan Bean to the moon's Ocean of Storms and near the robotic explorer Surveyor 3 (1969)
14th History: discovery of the Great Comet of 1680 or Kirch's Comet by Gottfried Kirch (1680)
15th History: launch of SpaceX's Crew-1 from the Kennedy Space Center, Florida, to the International Space Station
15th History: William Herschel born, German-English astronomer, credited with the discovery of Uranus, two of its moons, two of Saturn's moons and catalogued the heavens (1738)
15th History: ESA's spacecraft SMART-1 enters lunar orbit; first ESA Small Mission for Advanced Research in Technology; travelled to the Moon using solar-electric propulsion and carrying a battery of miniaturized instruments (2004)
15th History: the only orbital launch of the Russian space shuttle Buran; the unmanned shuttle orbited the Earth twice before landing (1988)
15th History: launch of Intasat, Spain's first satellite (1974)
16th Last Quarter Moon
16th Apollo Asteroid *2018 WH* near-Earth flyby (0.006 AU)
16th Apollo Asteroid *2019 VL5* near-Earth flyby (0.023 AU)
16th History: discovery of the Asteroid *21 Lutetia* by Hermann Goldschmid (1852)
17th Leonids Meteor Shower peak (associated with the comet Tempel-Tuttle)
17th Centaur Object *49036 Pelion* at Opposition (20.657 AU)
17th Kuiper Belt Object *474640 Alicanto* at Opposition (47.643 AU)
17th History: Surveyor 6 performs a "hop" maneuver, moving approximately 8 feet (2.5 meters) from its original landing area and enabling scientists to validate surface properties. This lunar "hop" was the first powered takeoff from the lunar surface. It also provided NASA a view of the original landing site and a baseline for acquiring stereoscopic images of its surroundings. (1967)
17th History: launch of Soyuz 20, a 90-day, long duration mission that carried a biological payload (tortoises) that docked with the Salyut 4 space station. The tortoises returned to Earth in good health (1975)
17th History: Soviet lunar lander Luna 17 deploys first rover - Lunokhod 1 (built by the Kharkov state bicycle plant); operated for 11 months, photographing and mapping the lunar surface and analyzing the regolith (1970)

Astronomical and Historical Events (continued)

18th Scheduled launch of a Dragon 2 cargo resupply spacecraft to the International Space Station from the Kennedy Space Station aboard a Space X Falcon 9 rocket
18th Kuiper Belt Object 2012 VP113 at Opposition (83.468 AU)
18th History: launch of the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft (Mars Orbiter) from the Cape Canaveral Air Force Station (2013)
18th History: launch of the COBE spacecraft; observed diffuse cosmic background radiation (1989)
19th Binary Plutino *341520 Mors-Somnus* at Opposition (28.060 AU)
20th Apollo Asteroid *217628 Lugh* closest approach to Earth (0.135 AU)
20th Apollo Asteroid *1620 Geographos* closest approach to Earth (0.721 AU)
20th History: the Japan Aerospace Exploration Agency's Hayabusa spacecraft lands on Asteroid 25143 *Itokawa* for sample collection (2005) (JST)
20th History: launch of the Swift spacecraft; first-of-its-kind multi-wavelength observatory dedicated to the study of gamma-ray bursts (2004)
21st Aten Asteroid 2019 OR1 near-Earth flyby (0.046 AU)
21st History: launch of Sentinel 6-Michael Freilich, a joint mission between the European Space Agency, NASA, NOAA, CNES and Eumetsat - continuing the work done by the Jason series of satellites on monitoring sea level.
23rd New Moon
23rd Kuiper Belt Object *90377 Sedna* at Opposition (82.880 AU)
23rd Apollo Asteroid *2005 LW3* near-Earth flyby (0.008 AU)
23rd Aten Asteroid *2014 BA3* closest approach to Earth (0.567 AU)
23rd Plutino 455502 (*2003 UZ413*) at Opposition (43.698 AU)
23rd History: launch of the Double Asteroid Redirection Test (DART) spacecraft from the Vandenberg Space Force Base, California – targeting the moon of the asteroid Didymos (2021)
23rd History: launch of the Chang'e 5 spacecraft - China's first lunar sample return (2020)
23rd History: launch of the European Space Agency's first satellite, Meteosat 1 (1977)
23rd History: launch of Tiros II weather satellite (1960)
24th Kuiper Belt Object 523645 (*2010 VK201*) at Opposition (47.192 AU)
24th History: launch of the Russian Prichal nodal module (docking port) to the International Space Station (2021)
24th History: first observations of a transit of Venus (1639)
25th Moon at perigee (closest distance to Earth)
25th History: Albert Einstein publishes his General Theory of Relativity (1915)
25th History: William Dawes discovers Saturn's C Ring (1850)
26th Plutino 84719 (*2002 VR128*) at Opposition (39.881 AU)
26th History: landing of NASA's InSight spacecraft on Mars' western Elysium Planitia (2018)
26th History: Mars Cube One 1 & 2, Mars flyby (launched with InSight to monitor landing) (2018)
26th History: launch of the Mars Science Laboratory (MSL) aboard an Atlas 5 rocket from the Cape Canaveral Air Force Station (2011)
26th History: discovery of Mars meteorites SAU 005 and SAU 008 (1999)
26th History: launch of France's first satellite, Asterix 1 (1965)
26th History: launch of Explorer 18; studied charged particles and magnetic fields in and around the Earth – Moon (1963)

Astronomical and Historical Events (continued)

26th History: discovery of the Orion Nebula by French astronomer Nicolas-Claude Fabri de Peiresc (1610)
27th History: Soviet spacecraft Mars 2 arrives at Mars; lander crashes, becoming first human artifact to impact the surface of Mars (1971)
28th History: launch of Algeria's first satellite, Alsat 1 (2002)
28th History: discovery of first Pulsar by Jocelyn Bell and Antony Hewish (1967)
28th History: launch of Mariner 4; first spacecraft to obtain and transmit close range images of Mars (1964)
29th History: discovery of Y000593 Mars meteorite in Antarctica (2000)
29th History: launch of Australia's first satellite, Wresat 1 (1967)
29th History: launch of Mercury 5 with Enos the chimpanzee (1961)
30th First Quarter Moon
30th History first telescopic observations of the Moon by Galileo Galilei (1609)

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

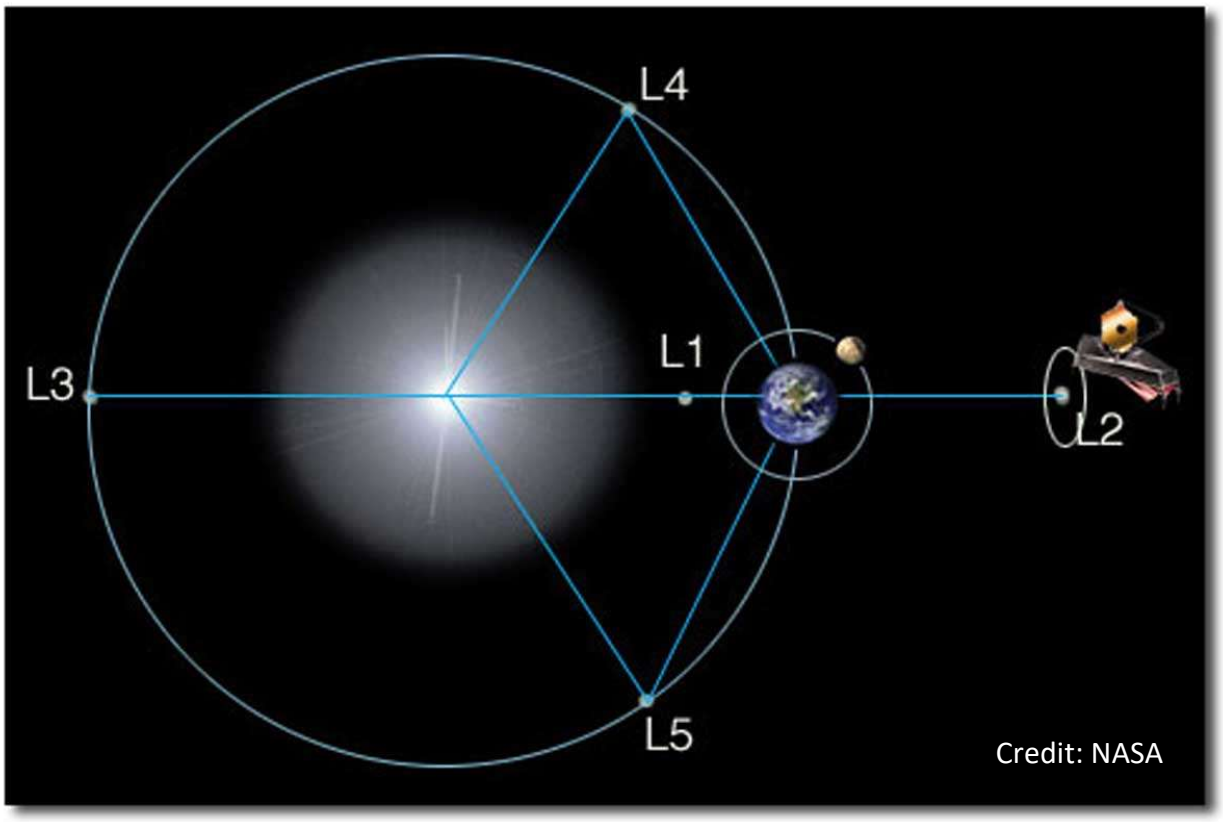
Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other man-made objects in low-Earth orbit.

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 future location of the James Webb telescope) is located almost a million miles (1.5 million km) beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

- https://www.jwst.nasa.gov/

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 InSight (lander): https://mars.nasa.gov/insight/

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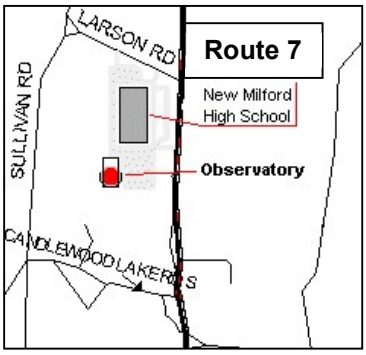

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