# Galactic Observer

## John J. McCarthy Observatory

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The Psyche spacecraft began its six-year journey to a metal asteroid on October 13th. The ride to orbit was provided by a SpaceX Falcon Heavy rocket booster from Launch Complex 39A at NASA's Kennedy Space Center in Florida.
Credit: NASA/Aubrey Gemignani

# November Astronomy Calendar and Space Exploration Almanac

On October 14th, spectators along a narrow path that stretched from Oregon to Texas were treated to a rare Annular Eclipse. This special class of a partial eclipse occurs when the Moon passes directly between the Sun and Earth and the Moon is at its farthest distance from Earth. As such, the Moon does not completely cover Sun, with the Sun forming a ring around the New Moon.

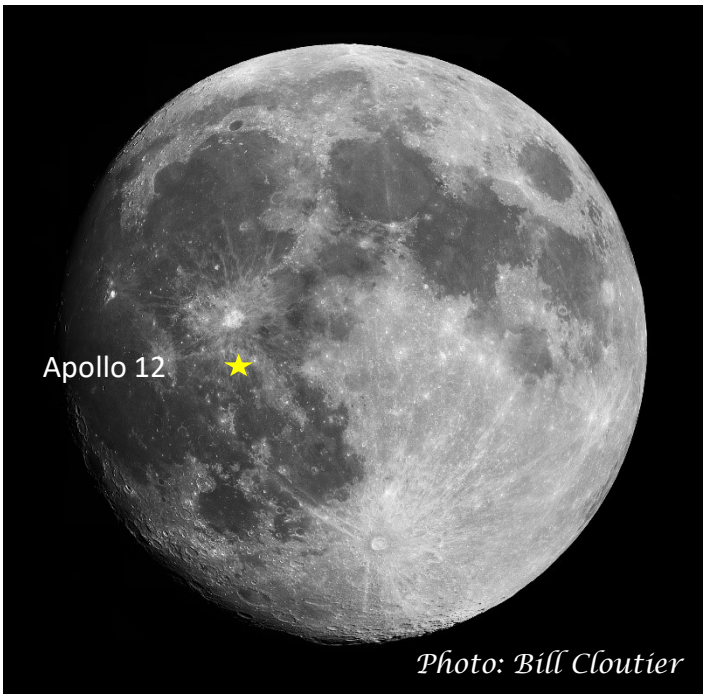
NASA TV image from Albuquerque, New Mexico

## In This Issue

"Out the Window on Your Left"

It's been 54 years since Neil Armstrong first stepped onto the Moon's surface and almost 51 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.



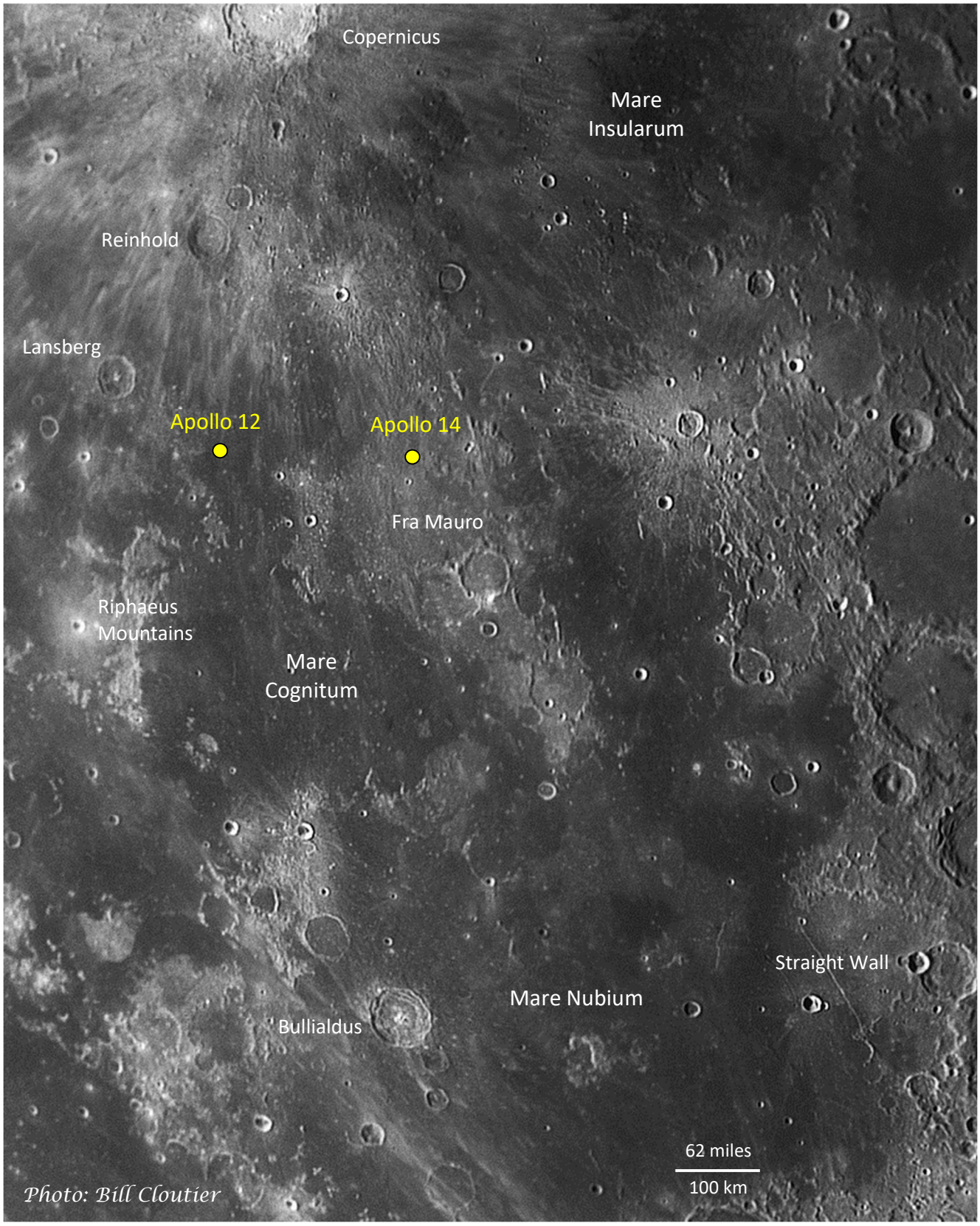

Apollo 12 landed approximately 930 miles (1,500 km) west of the Apollo 11's Tranquility Base. The site was selected for its proximity to Copernicus crater, 250 miles (400 km) to the north, and for the ejecta that was believed to have covered the area from that crater's formation. The location was also 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.

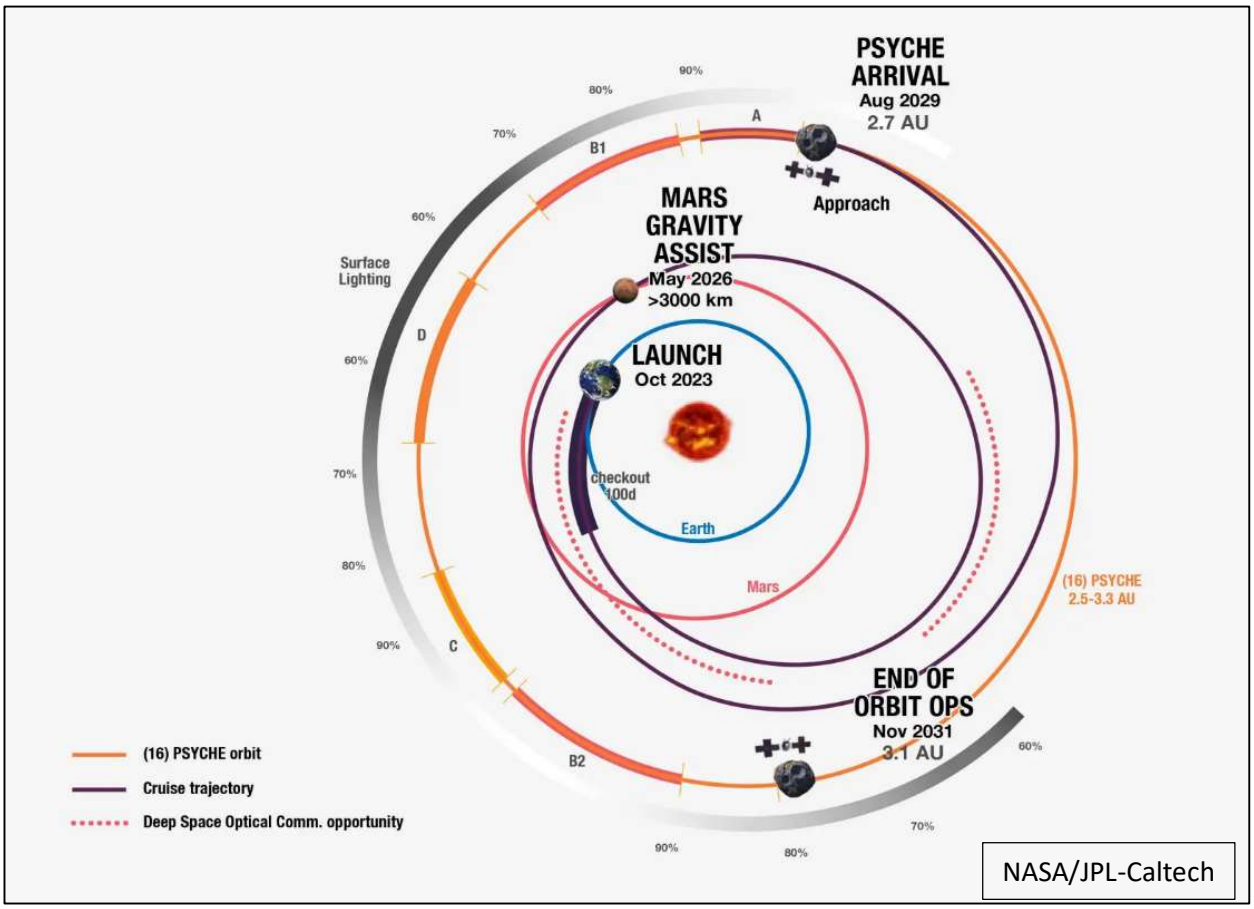
While Conrad and Bean were on the Moon, Command Module Pilot Richard Gordon remained in lunar orbit in the Command Module, the "Yankee Clipper," conducting photographic surveys of potential landing sites. These included the Fra Mauro region, which after the Apollo 13 abort, was redesignated as the target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

Psyche Launch

After a week-long technical delay and one-day weather hold, NASA's Psyche spacecraft lifted off from Pad 39A at Kennedy Space Center, Florida, on Friday, October 13th on a mission to a metal asteroid, also called Psyche. The ride to orbit aboard a SpaceX Falcon Heavy rocket booster was just the beginning of what will be a six-year journey to the outer asteroid belt.

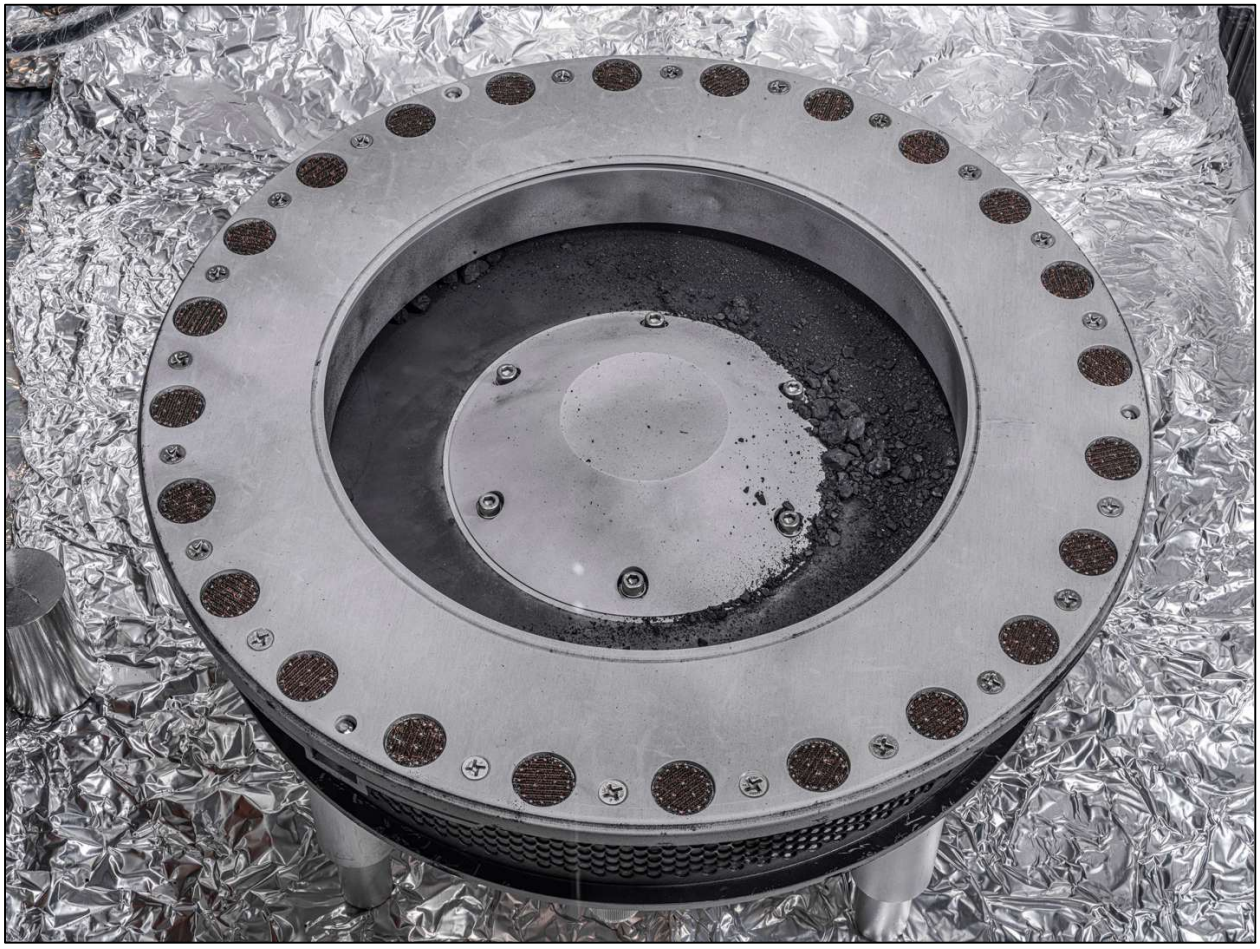



Psyche was discovered in 1852 by Italian astronomer Annibale de Gasparis. The sixteenth asteroid discovered; this minor planet is approximately three times farther from the Sun than Earth. Using radar and optical images, scientists have generated a 3D model of the irregular and potato-shaped world. At its widest, Psyche measures 173 miles (280 km), with its surface showing evidence of two large, craterlike depressions.

Psyche is different from other asteroids that have been visited in that it is comprised of a mixture of rock and metal, with a metal content somewhere between 30% to 60% of its volume. What is not known is whether the asteroid is the remnant of a planetesimal core or just enriched (in metallic elements) asteroidal material. The instruments onboard the spacecraft should provide scientists the data to discriminate among possible formation theories.

Once arriving in 2029, the spacecraft will survey the asteroid from four different orbits. Objectives include: measuring any strong residual magnetic fields, determining the relative age of Psyche's surface regions, measuring the global abundance of metallic and lighter elements, and characterizing the topography. Should the asteroid be an exposed core of a planetesimal, this mission will greatly enhance our understanding of planetary formation, the accumulation of matter that created planets in the early solar system, and provide a look inside what is likely at the center of other terrestrial planets, like Earth, and hidden from view by overlying rock layers.

Sample Retrieval

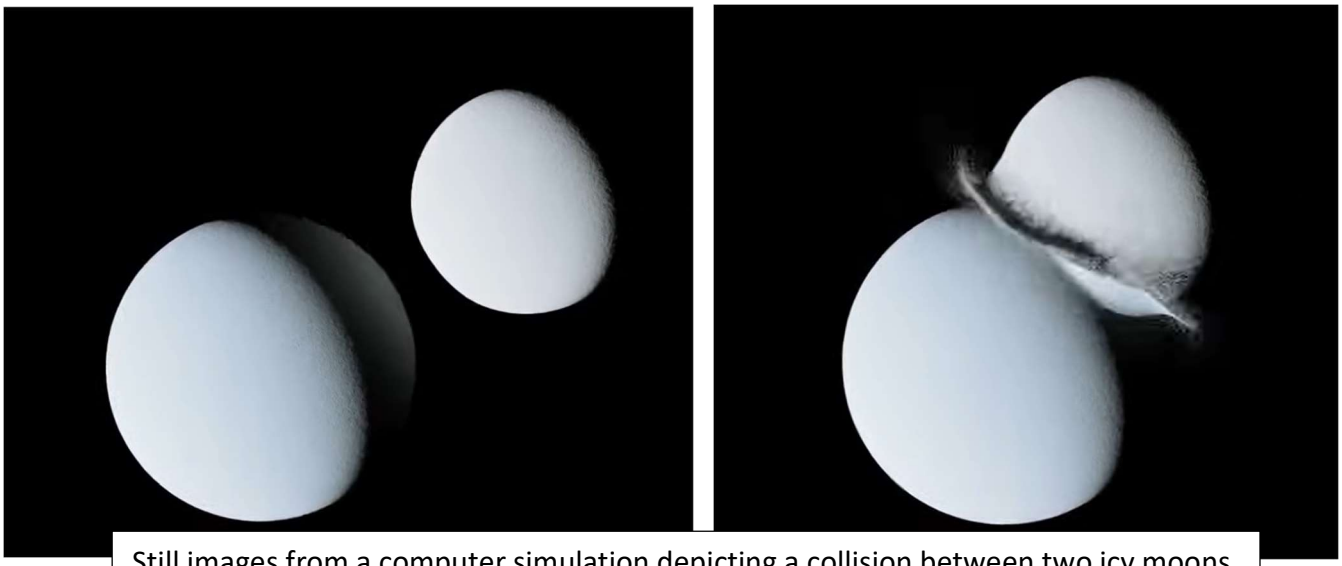


A view of the outside of the OSIRIS-REx sample collector and bonus sample material from asteroid Bennu.
Photo: NASA/Erika Blumenfeld & Joseph Aebersold

The sampling head from inside the OSIRIS-REx return capsule was delivered to NASA's Johnson Space Center in Houston on September 25th after landing in the Utah desert on the previous day. Since then, the curation team has been working in a clean room, built specifically for the mission, to remove the rock and dust collected by the spacecraft from the asteroid Bennu. So far, the team has collected 2.48 ounces (70.3 grams) of rock and dust from the hardware (NASA's goal was to return at least 60 grams to Earth). Additional material remains to be retrieved from inside the sampling head, but disassembly has been slowed when two of 35 fasteners on the mechanism could not be removed by the specialized tools approved for use in the glove box.

Initial analysis of the 4.5-billion-year-old asteroid Bennu sample shows evidence of high-carbon content and water. The material will be shared with scientists from around the world.

Saturn's Rings Creation Modeled



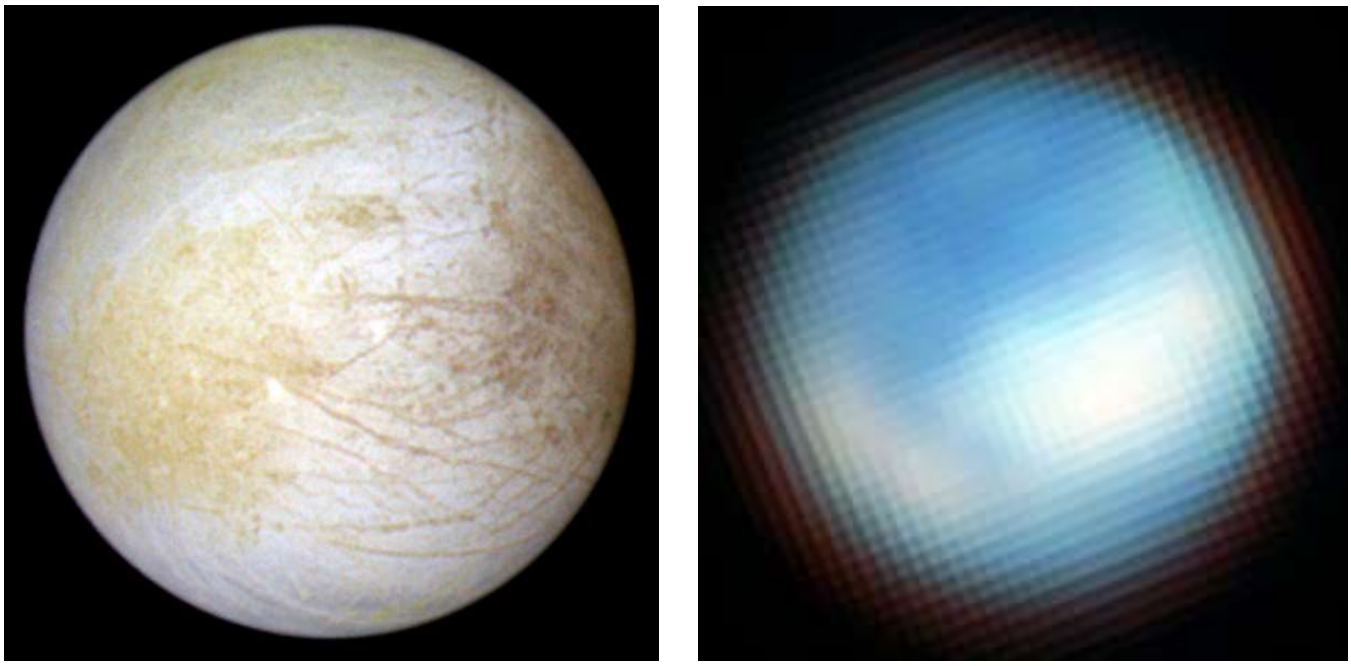
Still images from a computer simulation depicting a collision between two icy moons.
Credits: NASA/Durham University/Glasgow University/Jacob Kegerreis/Luís Teodoro

According to a recent computer analysis, Saturn's rings likely evolved from a collision of two icy moons a few hundred million years ago. A team of researchers simulated over 200 different versions of an impact, modeling over 30 million particles of ice and rocky material. They discovered a number of scenarios that could scatter just the right amount of ice within Saturn's Roche limit (the region near the planet in which gravitational force precludes the formation of larger bodies) where the rings reside. Debris deposited outside of the Roche limit could have contributed to the formation of Saturn's present-day moons.

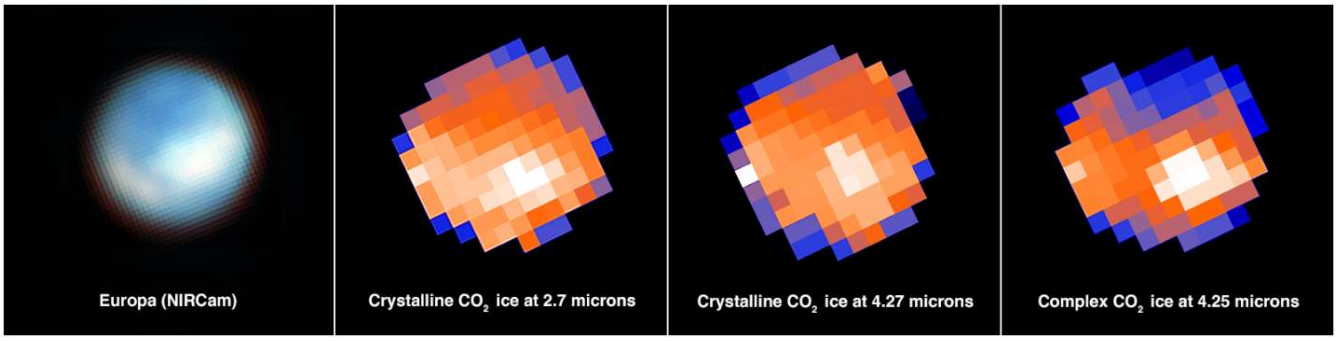
Cassini view of Saturn's rings
NASA/JPL-Caltech/Space Science Institute

Europa Biosignature?

NASA's James Webb Space Telescope has detected crystalline carbon dioxide on the icy surface of Jupiter's moon Europa. The deposit likely came from the subsurface ocean and not from an external source, such as meteorites, and also appears to be from a relatively recent (geologically) event. Life on Earth is carbon-based and its detection on other ocean worlds has important implications in the search for extraterrestrial life.

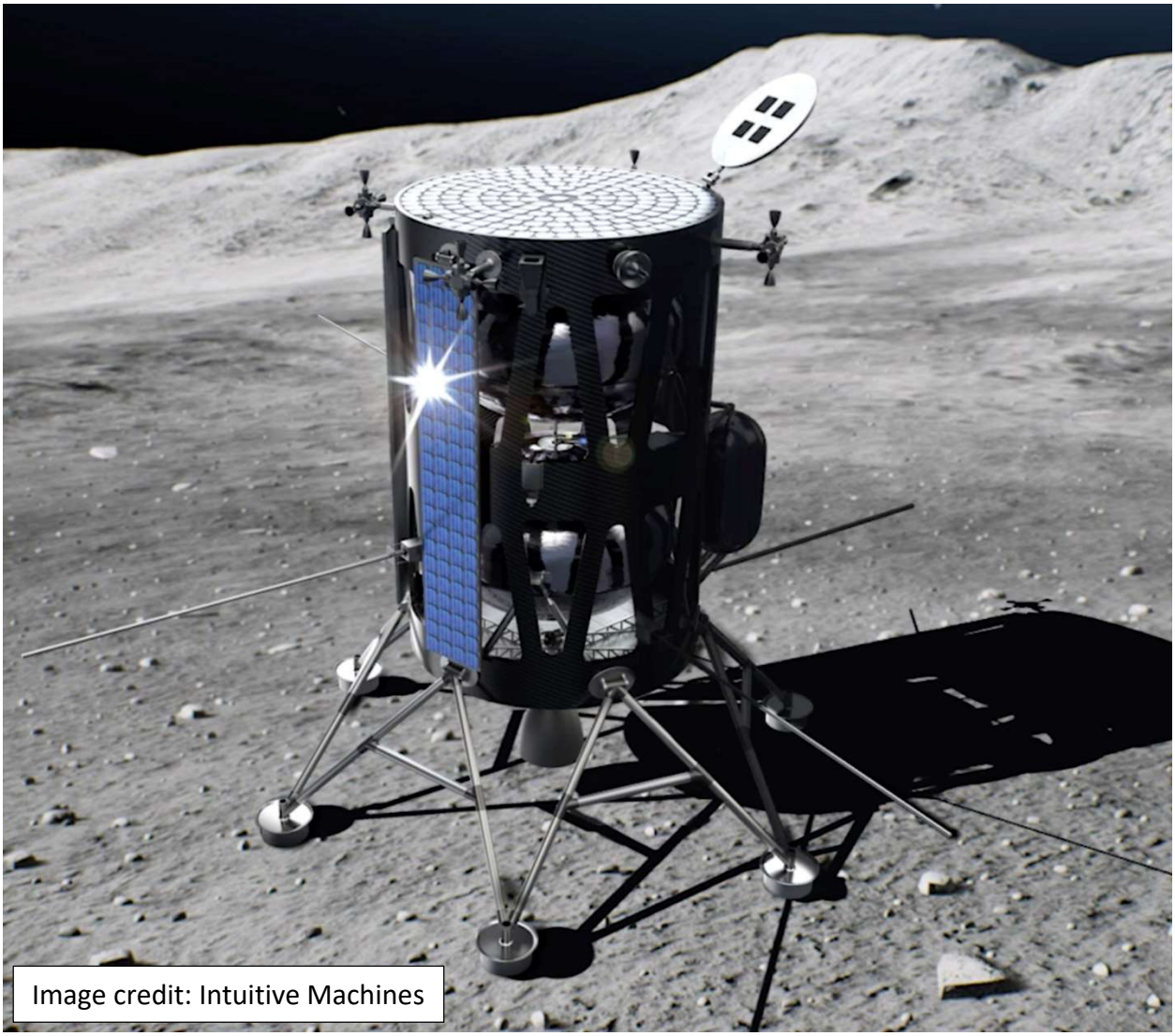


Europa in natural color (left) and with James Webb's Near Infrared Camera (NIRCam) (right) Sources: NASA/JPL/University of Arizona and Geronimo Villanueva (NASA/GSFC), Alyssa Pagan (STScI), respectively




Compositional maps derived from Webb's NIRSpec/IFU (Near Infrared Spectrograph's Integral Field Unit). The second and third panels show evidence of crystalline carbon dioxide, while the fourth panel indicates a complexed and amorphous form of carbon dioxide. The discovery corresponds to the regions identified as Tara Regio (center and right) and Powys Regio (left). Science Credit: Geronimo Villanueva (NASA/GSFC), Samantha Trumbo (Cornell Univ.), NASA, ESA, CSA. Image Processing Credit: Geronimo Villanueva (NASA/GSFC), Alyssa Pagan (STScI)

Lunar Delivery Service Starts



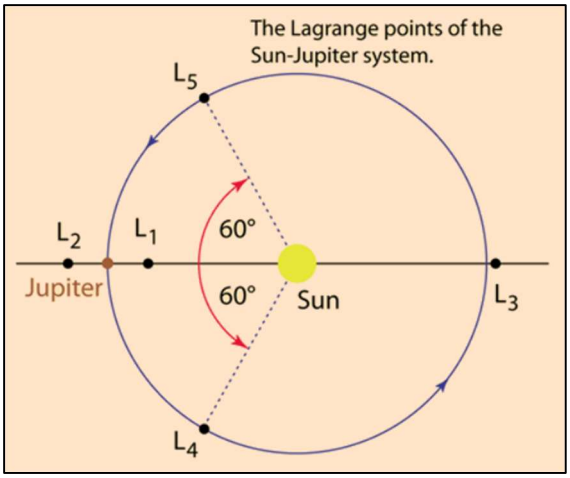

In support of the Artemis program ("Return to the Moon"), NASA has been working with several American companies to deliver science and technology to the lunar surface through its Commercial Lunar Payload Services (CLPS) initiative. The first of two scheduled for launch is Intuitive Machines' Nova-C spacecraft. The lander is a hexagonal cylinder, about 13 feet or 4.0 meters tall and 5.15 feet or 1.57 meters wide. Liquid methane (with liquid oxygen as the oxidizer) will power the main engine located at the base of the lander on the descent. Once on the lunar surface, solar panels will generate the electricity to run the experiments on the lander.

Nova-C is capable of carrying approximately 220 pounds (100 kg) of payload to the surface. For this first flight, the scientific payload includes a laser retro-reflector array, an optical navigation sensing device, a CubeSat-sized autonomous navigation demonstrator, stereo video cameras to collect engine plume data during landing, and a low-frequency radio receiver to assess the local photoelectron environment on antenna response, e.g., for a future lunar-based radio observatory.

Intuitive Machines' lander will set down on the rim of Malapert A, a crater near the Moon's south pole. Nova-C is expected to operate for one lunar day or about 14 Earth days.

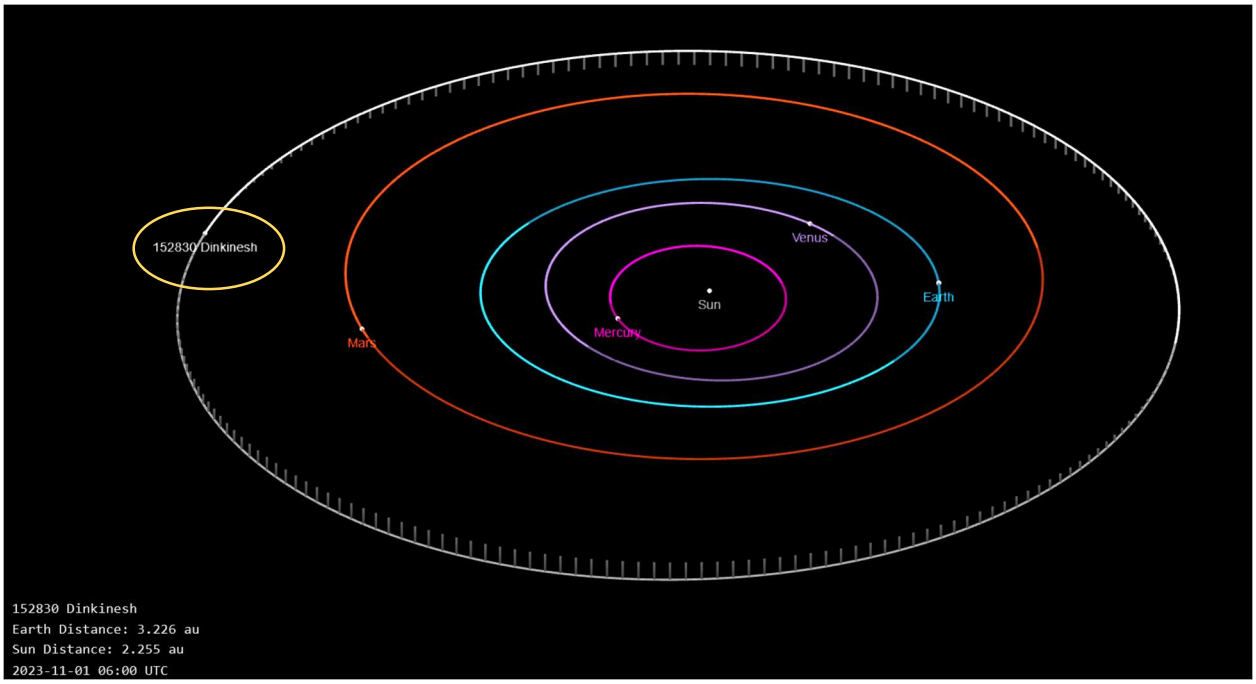
Lucy in the Sky – First Encounter

NASA's Lucy mission launched in 2021 on a 12-year mission to visit five asteroids (and satellites of three of the five) that share Jupiter's orbit (called Trojan asteroids) at two gravitationally stable locations. The asteroids are believed to be relics from the time of planetary formation. Since the mission was first planned, two additional "stops" have been added to the itinerary. The bonus encounters are both main belt asteroids.



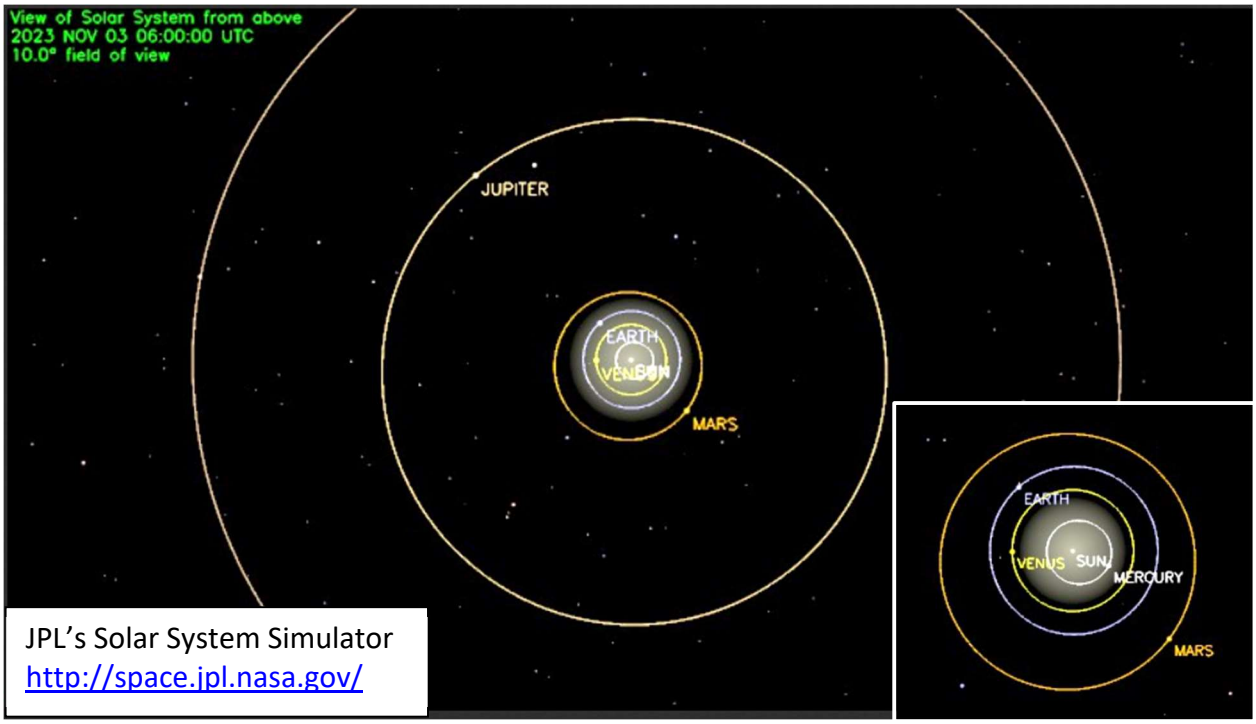

One cluster of Trojans precedes Jupiter (at the Lagrange $L_4$ position) while the other trails Jupiter (at $L_5$). To visit both, the spacecraft will take a rather circuitous route, skimming the inner regions of the main asteroid belt before heading back to Earth for a gravity assist that will propel Lucy out through the main belt to the $L_4$ group and asteroids Eurybates, Polymele, Leucus and Orus in 2027-28. The spacecraft will then return to Earth for another gravity assist that will send Lucy to the L5 region and the asteroid binary pair, Patroclus and Menoetius.

The spacecraft's first encounter with a minor planet occurs on November 1st as Lucy passes by a small rocky body, less than one-half mile across on the inner edge of the main asteroid belt called Dinkinesh (named for the Amharic name of the Lucy fossil). The flyby will provide an early opportunity for the Lucy team to test and calibrate the spacecraft's instruments in advance of its future scientific targets.




Dinkinesh at almost 300 million miles (480 million km) from Earth on November 1st
Source: JPL Small-Body Database – Orbit Viewer

Jupiter at Opposition



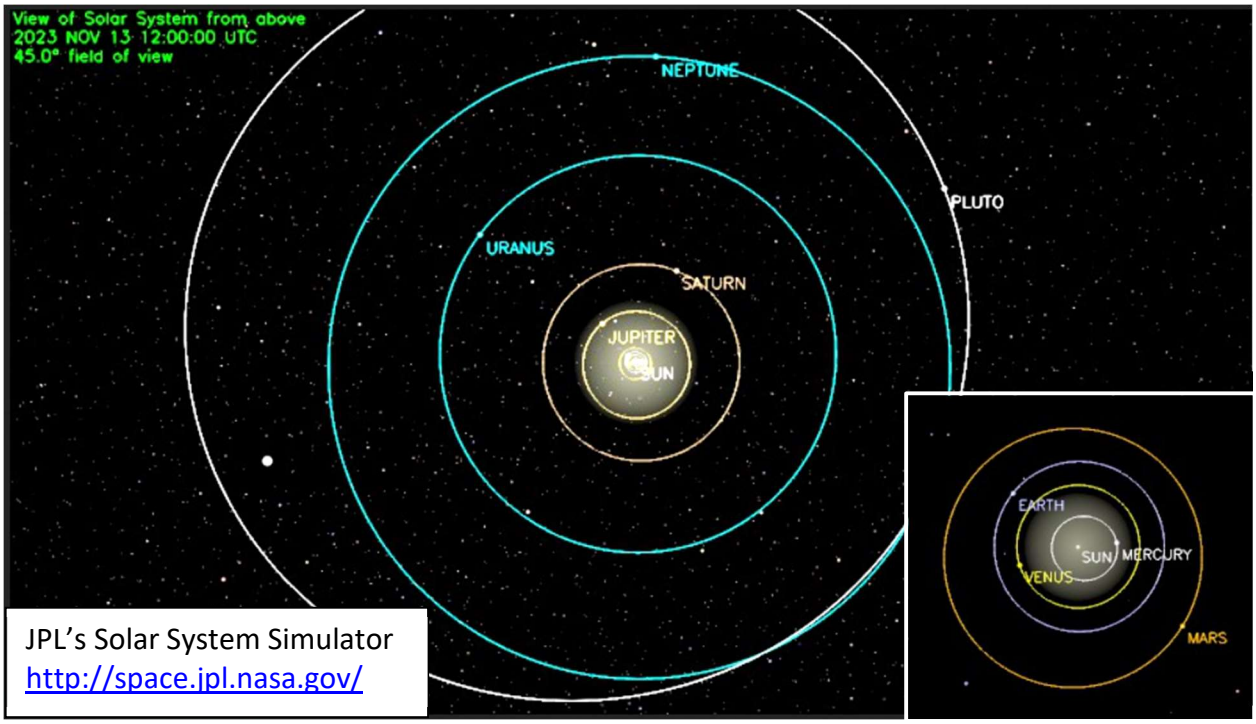

JPL's Solar System Simulator
http://space.jpl.nasa.gov/

Jupiter, the fifth planet from the Sun and largest in the solar system (more than twice as massive as all the other planets combined) is closest to Earth this year on November 1st, two days before Opposition. With a diameter of almost 87,000 miles (140,000 km), Jupiter is 11 times wider than Earth (if Jupiter was the size of a basketball, the Earth would be the size of a nickel). At last count, Jupiter has 92 moons, although only the four largest (the Galilean moons) are visible in binoculars or a small telescope. The Galilean moons: Io, Europa, Ganymede, and Callisto, were first observed by the astronomer Galileo Galilei in 1610. Ganymede is the largest moon in the solar system (larger than the planet Mercury), and Io the most volcanically active body. Europa, the target of NASA's Europa Clipper mission, is suspected to harbor a large liquid water ocean beneath its icy crust.

Jupiter makes a complete orbit around the Sun in 12 Earth-years and has the shortest day in the solar system (about 10 hours). It spins nearly upright with its equator tilted with respect to its orbital path around the Sun by just 3 degrees. Comprised primarily of hydrogen and helium, the gas giant is covered by layers of rapidly shifting clouds. The upper layer contains ammonia ice while underlying layers likely include ammonium hydrosulfide crystals, water ice and vapor. Nine spacecraft have visited Jupiter (seven flybys and two orbiters). The latest, NASA's Juno spacecraft, arrived in 2016 and currently orbits the gas giant once every 53 days. Its polar orbit is carrying the spacecraft closer to the moon Io with each successive pass, with closest approach coming in February 2024 at just 930 miles (1,500 km) above the volcano-strewn surface.

Io imaged from a distance of 7,270 miles (11,700 km) during Juno's 55th orbit or Perijove on October 15th
Credit : NASA/JPL-Caltech/SwRI/MSSS/Kevin M. Gill

Uranus at Opposition




The Earth will come between Uranus and the Sun on November 13th (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, between the Pleiades in Taurus and sea monster Cetus under ideal sky conditions. Uranus will be approximately 1.73 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.

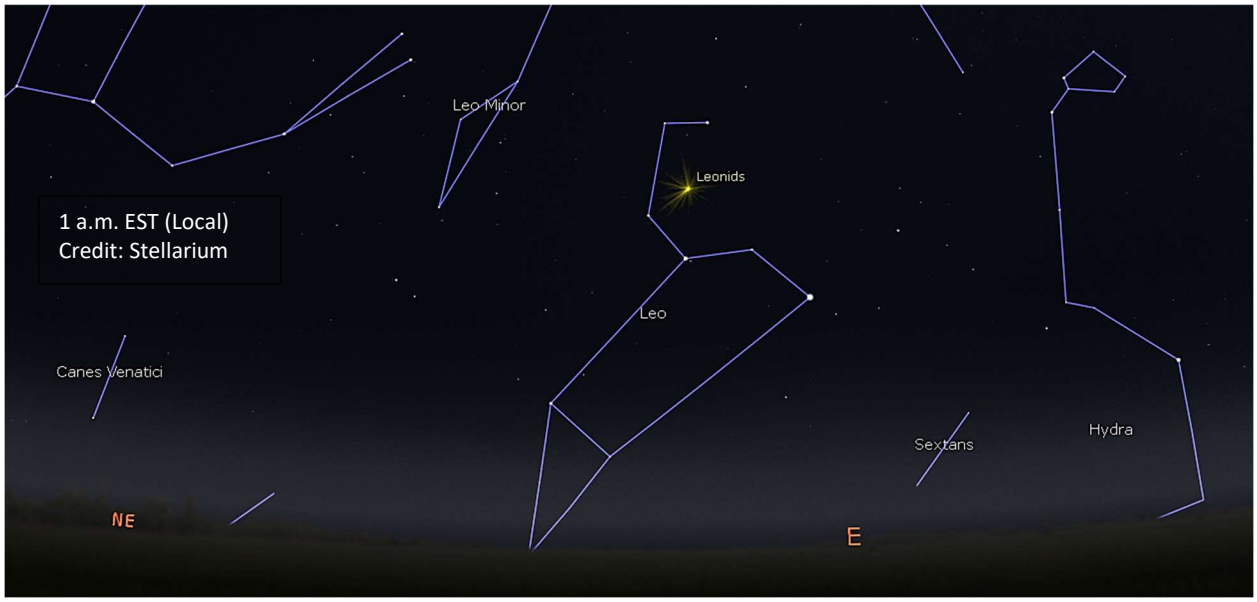
Leonid Meteor Shower

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 (or an asteroid). 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.

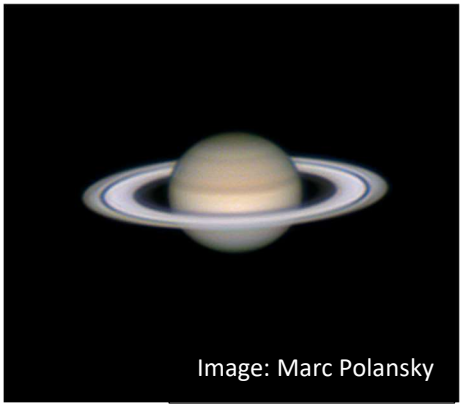
Why does the same meteor shower excite one year and disappoint the next? While comets are responsible for seeding Earth's orbit with the makings of a meteor shower, most comets are not frequent visitors to the inner solar system. Comet Tempel-Tuttle (the source of the Leonid meteors) crosses Earth's 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. This year the shower peak happens four days after a New Moon. Without interference from moonlight, even the shower's weaker meteors should be visible, with the best opportunity for viewing coming shortly after midnight.



Saturn

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




Jupiter

Jupiter reaches Opposition this year on November 3rd. At the beginning of the month, the gas giant shines brightly in the eastern sky after sunset (almost 30 times brighter than Saturn). The largest planet in the solar system can be found in the constellation Aries and to the east of Saturn.


| | Rise and Meridian Transit Times | | | |
|---|---|---|---|---|
| | November 1 (EDT) | | November 30 (EST) | |
| Planet | Rise | Transit* | Rise | Transit* |
| Saturn | 3:07 pm | 8:22 pm | 12:14 pm | 5:30 pm |
| Jupiter | 5:52 pm | 12:43 am | 2:48 pm | 9:35 pm |

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

Jovian Moon Transits

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

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

Jovian Moon Transits

| Date | Moon | Transit Begins | Transit Ends |
|---|---|---|---|
| | | | |
| 3rd | Europa | 9:15 pm | 11:34 pm |
| 4th | Io | 10:57 pm | 1:07 am (5th) |
| 6th | Io | 5:26 pm | 7:36 pm |
| 10th | Europa | 10:51 pm | 1:10 am (11th) |
| 13th | Io | 7:21 pm | 9:31 pm |
| 17th | Ganymede | 5:04 pm | 6:45 pm |
| 20th | Io | 9:16 pm | 11:26 pm |
| 24th | Ganymede | 9:06 pm | 10:47 pm |
| 27th | Io | 11:12 pm | 1:22 am (28th) |
| 28th | Europa | 5:20 pm | 7:39 pm |
| 29th | Io | 5:41 pm | 7:51 pm |

Great Red Spot Transits

The Great Red Spot is a large, long-lived cyclone in the upper Jovian atmosphere. The Earth-size storm will cross the center line of the planetary disk on the following evenings during the hours between 8 pm to midnight local time.

| Date | Transit Time | Date | Transit Time |
|---|---|---|---|
| | | | |
| October 31st | 10:44 pm | 17th | 8:43 pm |
| 3rd | 8:13 pm | 19th | 10:21 pm |
| 5th | 8:51 pm | 21st | 11:59 pm |
| 7th | 10:29 pm | 22nd | 7:51 pm |
| 10th | 7:58 pm | 24th | 9:29 pm |
| 12th | 9:36 pm | 26th | 11:07 pm |
| 14th | 11:14 pm | 29th | 8:36 pm |
| 15th | 7:05 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 Apollo asteroid and Near-Earth Object (NEO) 2013 UV3 closest approach to Earth
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 Aten asteroid and NEO 2016 WY closest approach to Earth
2nd Aten asteroid, NEO and Potentially Hazardous Asteroid (PHA) 363505 (2003 UC20) closest approach to Earth
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 Apollo asteroid and NEO 2022 JF closest approach to Earth
3rd Apollo asteroid, NEO and PHA 2023 QP8
3rd Apollo asteroid and NEO 2016 VW2 closest approach to Earth
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 Apollo asteroid and NEO 2019 UH7 closest approach to Earth
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 Last Quarter Moon
5th End of Daylight Saving Time - set clocks back one hour at 2 a.m.
5th Scheduled launch of a SpaceX Dragon 2 spacecraft on a cargo resupply mission to the International Space Station from the Kennedy Space Center, Florida
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)

Astronomical and Historical Events (continued)

6th Moon at apogee (furthest distance from Earth)
6th History: launch of Lunar Orbiter 2, Apollo landing site survey mission (1966)
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)
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 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 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 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 Second Saturday Stars – Open House at the McCarthy Observatory (7:00 pm)**
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 Amor asteroid and NEO 2023 TZ2 closest approach to Earth
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 New Moon
13th Uranus at Opposition
13th Aten asteroid and NEO 2014 BA3 closest approach to Earth
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 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)

Astronomical and Historical Events (continued)

15th Aten asteroid and NEO 2021 TN3 closest approach to Earth
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 Aten asteroid and NEO 2019 VL5 closest approach to Earth
16th History: launch of Artemis 1, an unmanned Moon mission, from the Kennedy Space Center aboard NASA's Space Launch System (2022)
16th History: discovery of the Asteroid *21 Lutetia* by Hermann Goldschmid (1852)
17th Leonids Meteor Shower peak (associated with the comet Tempel-Tuttle)
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)
18th Aten asteroid and NEO 2019 LB1 closest approach to Earth
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 Apollo asteroid and NEO 2016 DK1 closest approach to Earth
19th Aten asteroid and NEO 2022 VR1 closest approach to Earth
20th First Quarter Moon
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 Moon at perigee (closest distance to Earth)
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 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)

Astronomical and Historical Events (continued)

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 Apollo asteroid and NEO 2019 UT6 closest approach to Earth
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 Apollo asteroid and NEO 2019 CZ2 closest approach to Earth
25th History: Albert Einstein publishes his General Theory of Relativity (1915)
25th History: William Dawes discovers Saturn's C Ring (1850)
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)
26th History: discovery of the Orion Nebula by French astronomer Nicolas-Claude Fabri de Peiresc (1610)
27th Full Moon (Beaver Moon)
27th Aten asteroid and NEO 2013 UB3 closest approach to Earth
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 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

Commonly Used Terms (continued)

- 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 4$^{th}$ and 5$^{th}$ 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.

NASA's Global Climate Change Resource

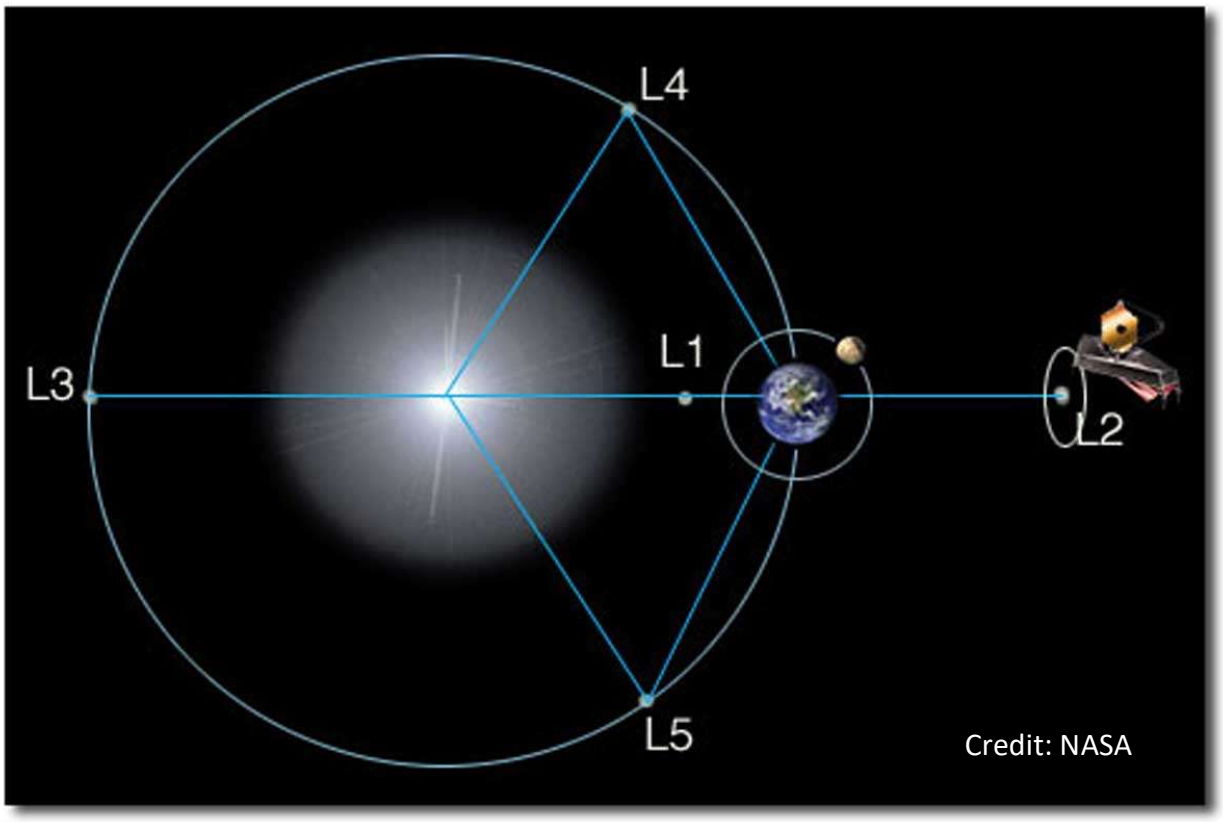
- Vital Signs of the Planet: https://climate.nasa.gov/

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/

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 James Webb telescope) is situated 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/

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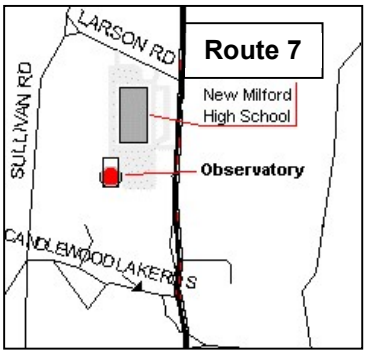


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