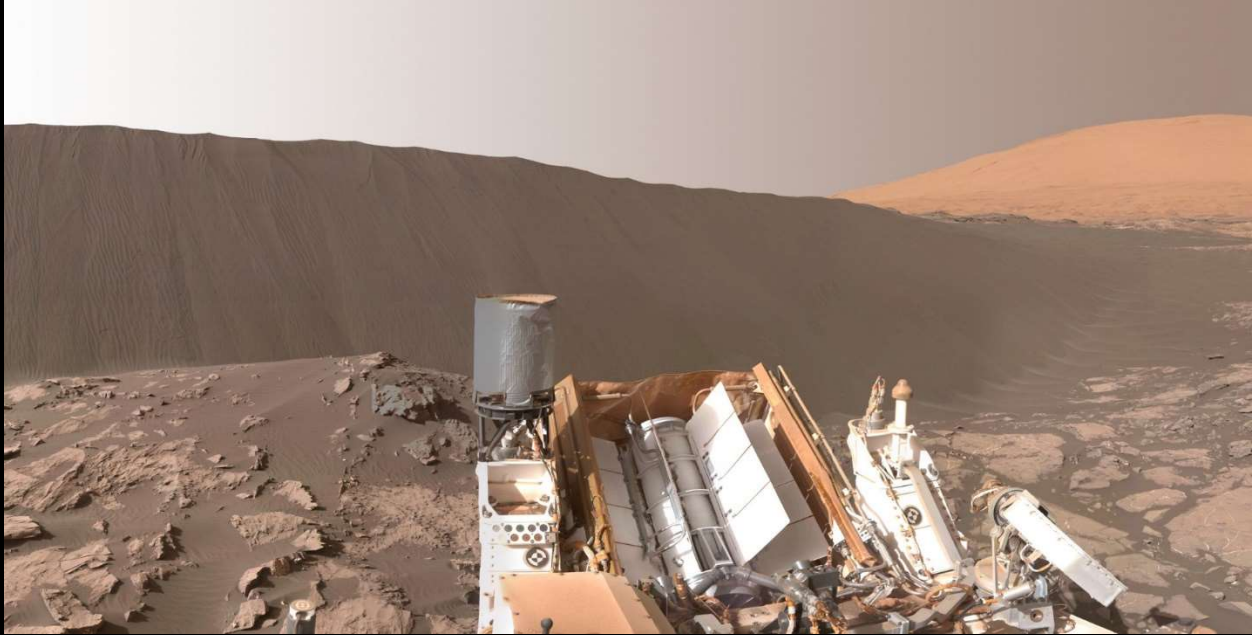


Galactic Observer

John J. McCarthy Observatory

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Arrakis Worthy

Downwind face of "Namib Dune" captured by the Mars Curiosity rover, including a portion of Mount Sharp on the horizon (upper image)

Image Credit: NASA/JPL-Caltech/MSSS

May Astronomy Calendar and Space Exploration Almanac



Fully Eclipsed Moon
Photo: Bill Cloutier

On the night of May 15-16, the Moon will slide into the Earth's shadow for the first Total Lunar Eclipse in over three years (visible from the east coast). Totality begins at 11:29 pm on the 15th and lasts about 85 minutes. Event timing on page 5.

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“Out the Window on Your Left”

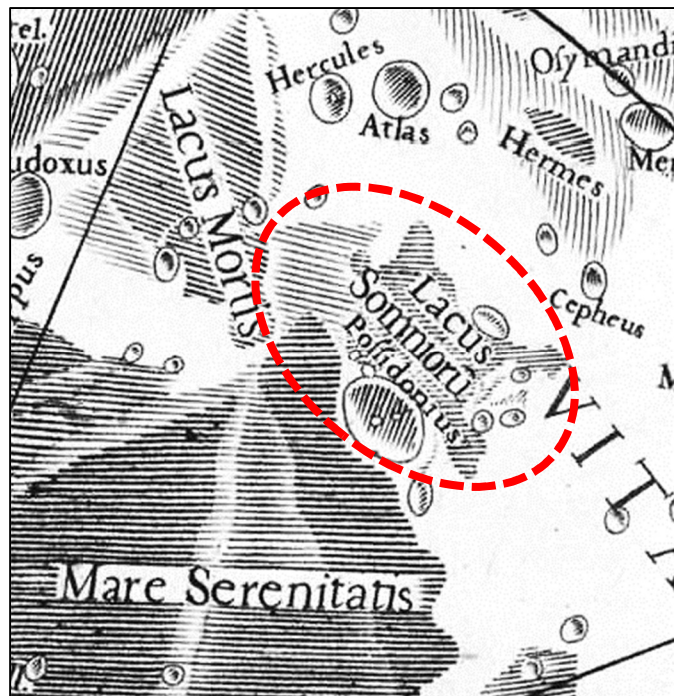
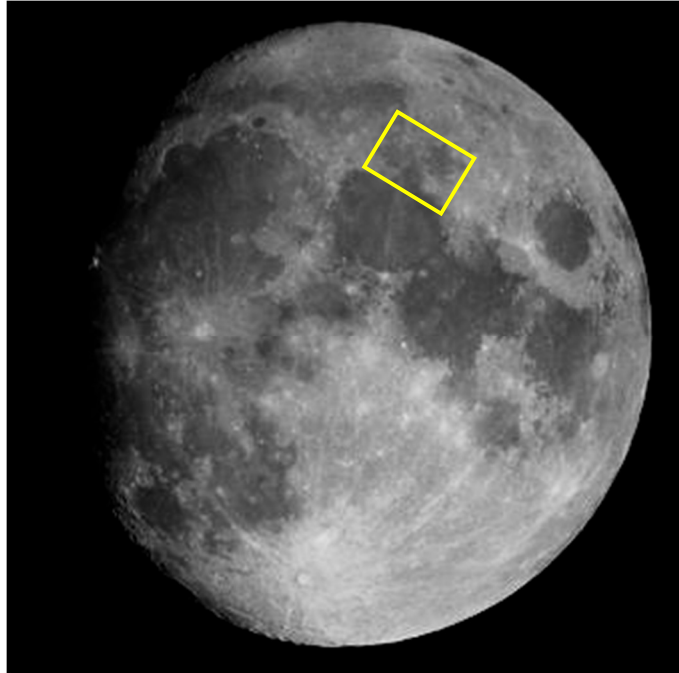
It's been almost 53 years since Neil Armstrong first stepped onto the Moon's surface and more than 49 years since Gene Cernan left the last footprint. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the Moon has been as fleeting as the funding. But 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).

This month we visit a small expanse of lava with a whimsical name - Lacus Somniorum ("Lake of Dreams"). The basaltic plain is located in the northeastern sector of the Moon's near side. The feature is connected to and divided into two regions by a prong of Mare Serenitatis. The large crater Posidonius marks the entrance.

Lacus Somniorum has an estimated surface area of 18,000 square miles (47,300 sq km) and a depth of 1.55 miles (2.49 km). The small mare is traversed by a number of rilles or channels, which are likely associated with the formation of the adjacent impact basin.

The Daniell rille slashes diagonally across Lacus Somniorum for 87 miles (140 km) to the northeast of the bright 3.6-mile (6-km) Daniell D crater. On the southern boundary is the G. Bond rille, cutting through mixed terrain for 104 miles (167 km).

Posidonius is a 59 mile (95 km) fractured-floor crater, a class of craters with a shallow, mare-flooded floor, concentric and radial rilles, dark halo craters, and a location near a mare. The floor is not only fractured (likely from the intrusion of lava from beneath) but tilted, creating a cliff that drops to the smooth floor. The moat created by the cliff on the eastern side is in deep shadow in the image on the following page.



Map of the Moon by the Italian Jesuit astronomer Giovanni Battista Riccioli (1598-1671), published in 1651 in *Almagestum Novum*

Lacus Somniorum

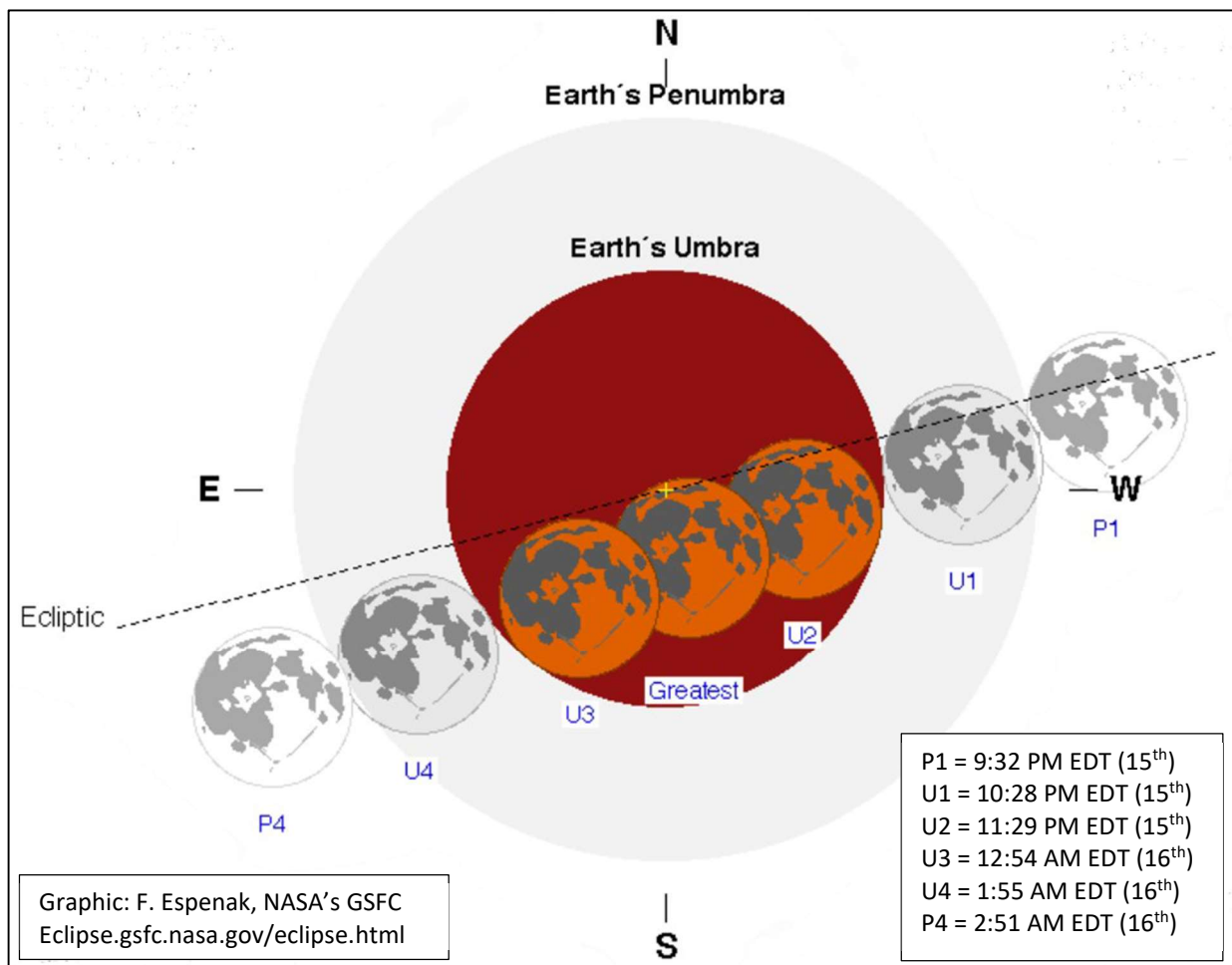


View of the northeast quadrant, centered on Posidonius crater, around six days after a New Moon with the eastern shore of Mare Serenitatis illuminated. Photo: Bill Cloutier

Flower Moon Total Lunar Eclipse

Just before midnight on May 15th, viewers on the east coast will see the Full 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 brighter as it is closest to the edge of the umbra.

On May 15-16th, the Moon will travel through the southern half of the umbra. The eclipse will be visible (weather permitting) with totality starting at 11:29 pm EDT and lasting about 85 minutes. May's Full Moon is considered a supermoon (larger than average), as a result of being close to the point in its orbit nearest to the Earth (perigee), which occurs on the 17th.

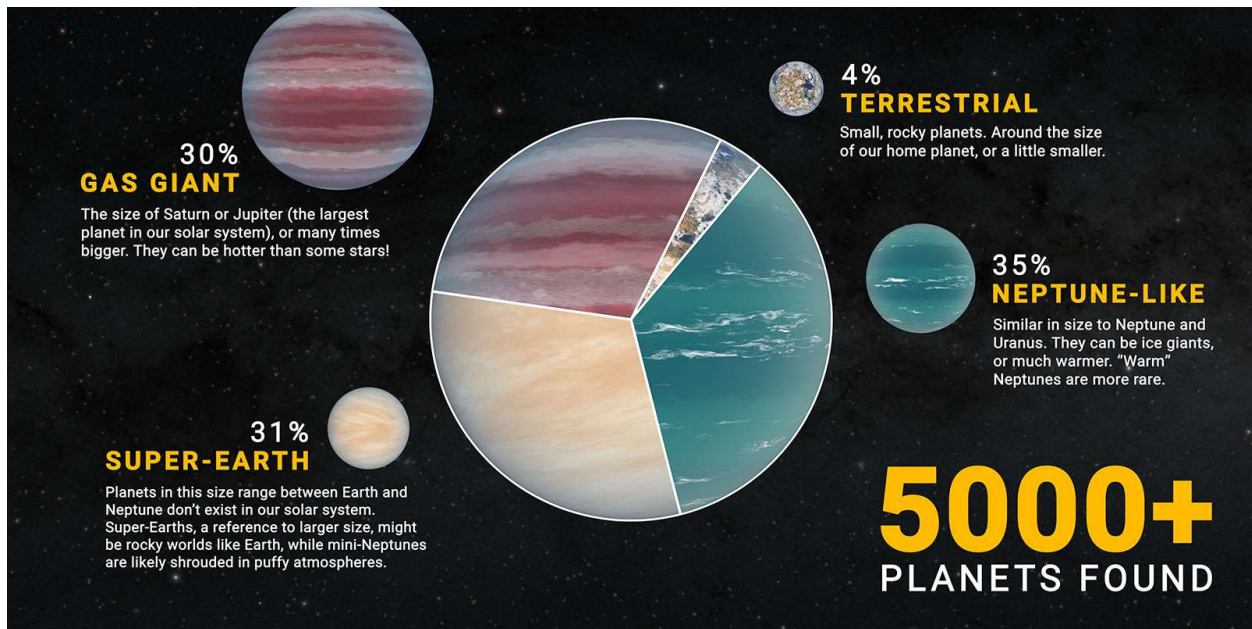


May's eclipse will be visible in the southeast, with the Moon about 26° above the horizon at the start of totality. The total eclipse phase will conclude just before 1 AM with Moon about 28° above the horizon and just past the meridian (due south). The next lunar eclipse will be on November 8th. Unfortunately, from the east coast, the eclipse will occur as the Moon is setting in the west in the early morning, although it does present a nice photographic opportunity to frame the darkened Full Moon on the horizon. After that, it's a rather long wait until March 2025 for the next event.

Milestone: 5000 Exoplanets

Thirty years ago, multiple planets were detected orbiting a neutron star (a stellar corpse/remnant of a supernova). It was only the second instance of an exoplanet(s) discovery (according to NASA's database). The initial discoveries prompted additional searches by Earth-bound and dedicated space telescopes (e.g., Kepler and TESS) that have accelerated the discovery of new worlds. On March 21st, NASA's Exoplanet Archive added the latest batch of confirmations, pushing the total over the 5,000 mark.

The diversity of worlds found has challenged every theory of how a planet would, could and should form along with its relationship to the host star(s). The majority of worlds (76.7%) have been discovered by the "transit" method (detected by the dimming of starlight as the planet passes directly between the star and observer). Other methods include "radial velocity" (18.3%) where orbiting planets cause stars to wobble and an observable shift in the color of the star's light, "microlensing" (2.6%) where light from a distant star is bent and focused by gravity as a planet passes between the star and Earth, and "direct imaging" (1.2%).



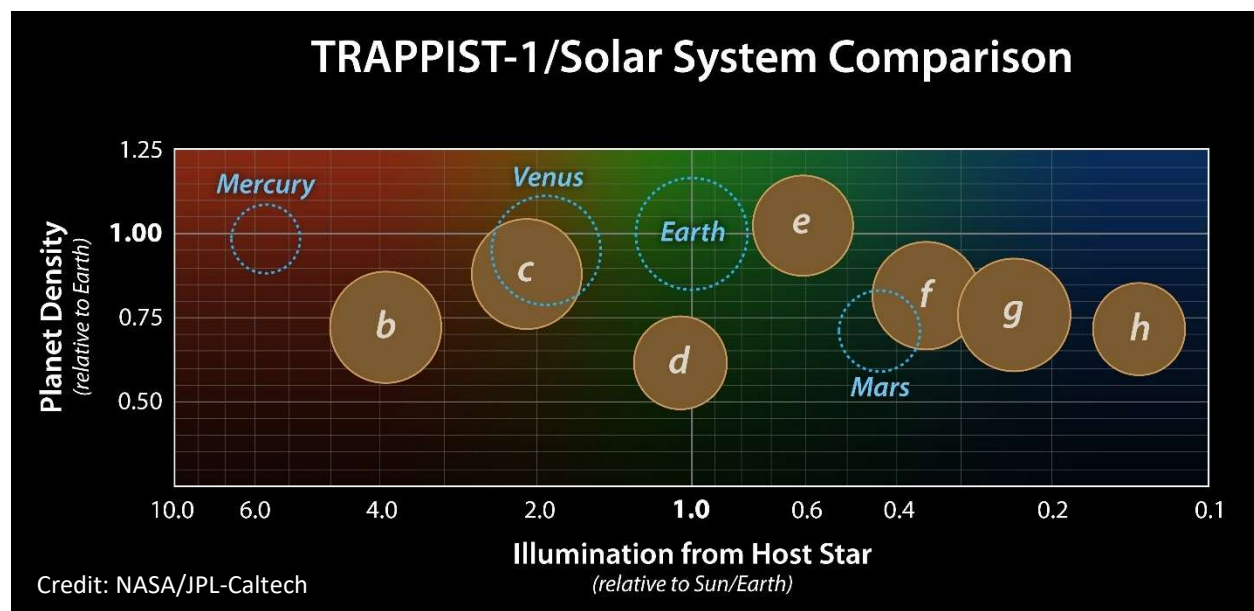
Early discoveries were Jupiter-sized, but as the detection methods improved, the discovery of smaller and more Earth-like planets became possible. Some of the more curious worlds include:

- *Kepler-16b*, discovered in 2011, is a "Star Wars" world where two suns transit the sky, the first Tatooine-like planet found in our galaxy
- *WASP-12b*, discovered in 2008, is classified as a hot Jupiter and is being torn apart by its star, which is so close that the egg-shaped planet takes only a day to complete an orbit
- *55 Cancri e*, a planet discovered in 2004, is so hot that it is believed to be covered with a global ocean of lava
- *AU Microscopii b* is a gas giant discovered in 2020. Located less than 32 light-years from Earth, it is among the youngest planetary systems found to date
- *GJ 15Ac*, discovered 2018, orbits a red-dwarf star with its companion. At just 11 light-years away, it is the nearest multi-planet system discovered so far

- *HD 80606 b*'s highly elliptical orbit is a sun-grazer, likely causing supersonic winds and shockwave storms across the planet at closest approach
- *Kepler-22b*, discovered 2011, is a possible ocean world as it orbits within the habitable zone of its star

At the latest count, 2,070 planets have been detected within multi-planet solar systems. The system with the most planets is called Kepler-90, with eight, but the most intriguing system is TRAPPIST-1. The red dwarf star is home to a family of seven Earth-size planets. The rocky worlds, located 41 light years away, are believed to be twice as old as our solar system.

While all seven planets would fit within the orbit of Mercury, TRAPPIST-1 is less than 10% the size of our Sun and much cooler. The fourth planet, called *TRAPPIST-1e* is right in the middle of the Goldilocks zone, the habitable area where liquid water can exist on the surface. The system is likely to be an early target of the James Webb Space Telescope, which may be able to detect whether any of the TRAPPIST worlds have an atmosphere.



The seven TRAPPIST-1 exoplanets are labeled b through h. Outlines of the four rocky planets in our solar system are shown for comparison of size, density and illumination. The data was collected from observations by NASA's Spitzer, Kepler and Hubble space telescopes, as well as a number of ground-based telescopes).

While multi-planet solar systems have been relatively common, the exoplanet search has also revealed planet(s) orbiting multiple stars. One of the most recent confirmations is the KOI-5 star system. It consists of three stars: star A and B orbit each other every 30 years with star C orbiting stars A and B every 400 years. The system hosts one known planet, called *KOI-5Ab*. The planet is about half the mass of Saturn and orbits star A roughly every five days. Its orbit is tilted 50 degrees relative to the plane of stars A and B, likely due to the gravitational effects of star B.

The search has only just begun, with new telescopes and detection methods there are likely millions of planets in our galaxy waiting to be discovered.

Hubble Space Telescope Spots Most Distant Star

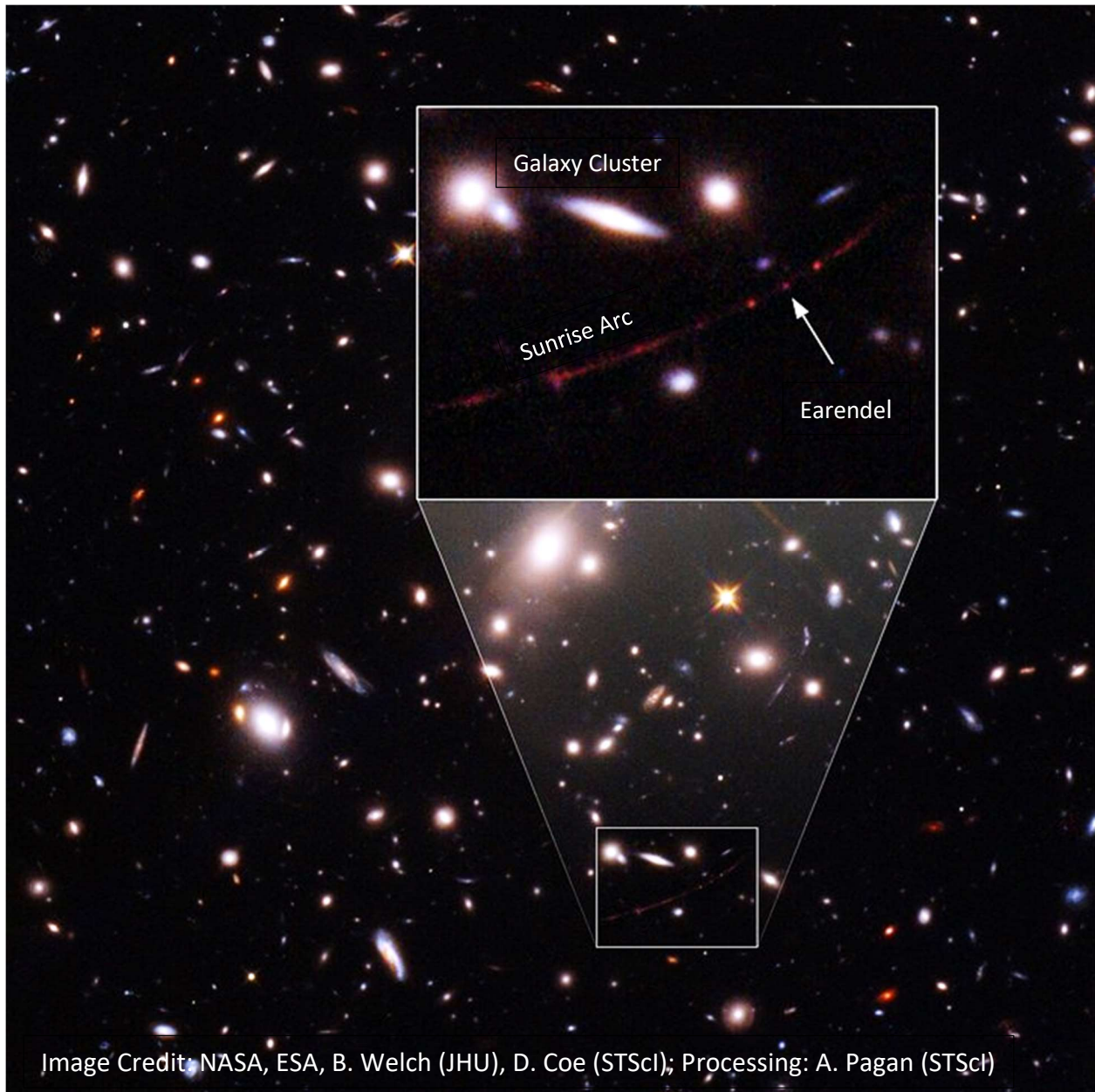


Image Credit: NASA, ESA, B. Welch (JHU), D. Coe (STScI); Processing: A. Pagan (STScI)

Acting like a magnifying glass, a large intervening galaxy cluster has magnified and intensified the light from an ancient galaxy and a massive star within that galaxy (at least 50 times as massive as our Sun and millions of times as bright). The light from the galaxy has been distorted by the gravity of the cluster into a long thin crescent - named the “Sunrise Arc.” The ability to distinguish a single star is due to a chance alignment along a ripple in spacetime that provides maximum magnification and brightening. The light from the star, named Earendel, has taken 12.9 billion years to reach Earth, appearing as it did when the universe was just 900 million years old.

The team that named Earendel, which means “morning star” in Old English, was inspired by a half-elven mariner in J.R.R. Tolkien’s mythological classic “The Silmarillion.” The star is likely to be another early target of the James Webb Space Telescope, which may be able to provide details on its chemical composition, type and evolutionary stage.

Shared Magnetic Field?



The Moon was much closer to the Earth when its first

The Full Moon as seen from the ISS, 254 miles above the Pacific Ocean
Image credit: NASA

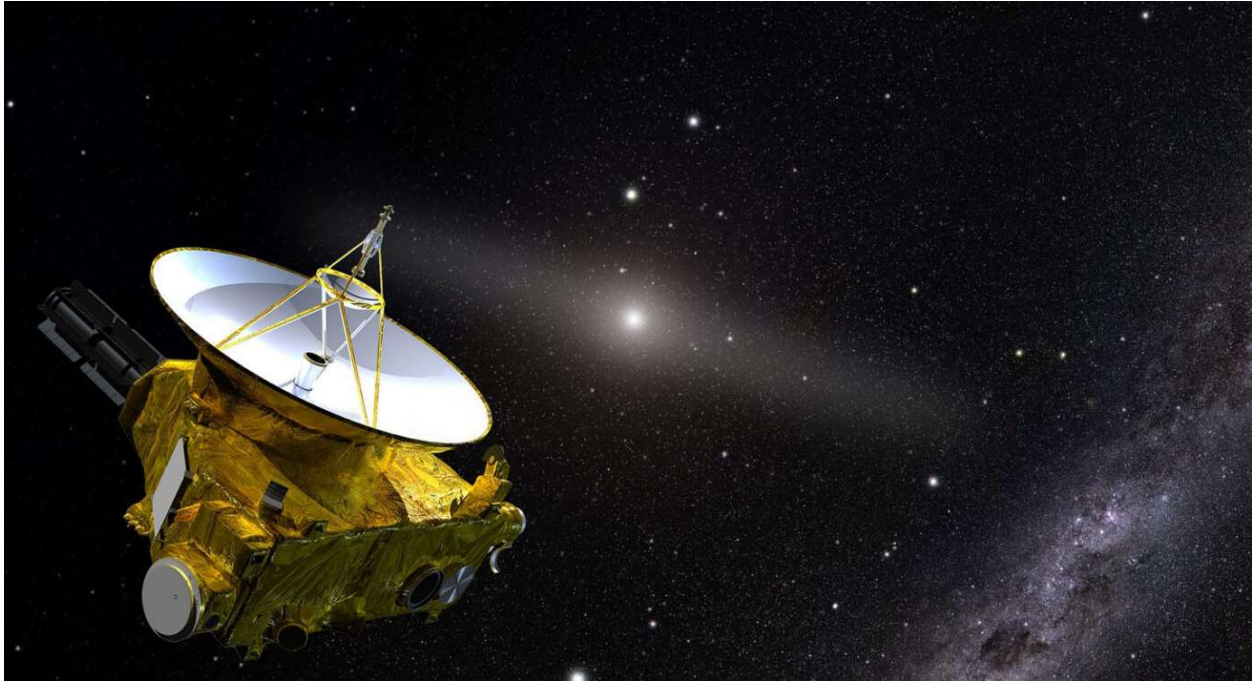
formed almost 4.5 billion years ago and has been slowly retreating ever since (currently at a rate of about 1.5 inches each year or 3.8 cm). While the rate has varied over time, scientists are able to monitor the distance between the two worlds to great precision, in part, due to the retroreflectors left behind on the Moon by the Apollo astronauts and affixed to the Soviet Lunokhod rovers, using a technique known as laser ranging.

The Moon no longer has a magnetic field, but conditions were much different billions of years ago when our natural satellite's interior was a hot, molten broth containing liquid iron and nickel that generated a magnetosphere. Before the interior cooled, the magnetosphere protected the tenuous lunar atmosphere from the scouring solar wind. A new study, which describes the results of computer modeling the Moon's early magnetic field, also reveals that it was likely shared and connected to Earth's magnetic field (4 billion years ago, when the Moon was one-third as far away as it is today).

The Moon's magnetic field diminished significantly 3.2 billion years ago, and vanished by about 1.5 billion years ago, but its presence when the Sun was young and more active, may have helped the Earth retain its atmosphere and habitability and from the penetrating radiation of powerful solar flares and the rain of charged particles. The coupling of magnetic fields may have also allowed the Earth's atmosphere to be shared with the Moon, as charged particles traversed the field lines between the two worlds.

Twice as Bright

Seven years after its encounter with Pluto and traveling an additional two billion miles, the New Horizon's spacecraft is still engaged in scientific endeavors. Now that the spacecraft is at the solar system's edge, away from its dusty disk, researchers have used its LORRI camera in an attempt to measure the Cosmic Optical Background (COB) or the visible background glow of the universe.



When all known sources of light (for example, the light from nearby bright stars, and galaxies) are removed from an observation, what remains should be the glow from distant galaxies, first generation stars, and any luminous nebulosity. In September 2021, researchers pointed New Horizon's LORRI camera to a point in the sky devoid of nearby stars and galaxies. The images were then processed to remove all known sources of light, and even heat from the spacecraft's radioisotope thermoelectric generator, to estimate the COB. The results were somewhat surprising and mystifying - the measured COB was twice as bright as expected (based on known galaxies that have been observed in deep sky surveys, such as those conducted by the Hubble Space Telescope).

New Horizon's vantage point as the edge of the solar system
Credit: NASA, Joseph Olmsted/STScI

Researchers plan on taking additional images in an attempt to explain the discrepancy. The recently launched James Webb Space Telescope will be able to see further back in time and could reveal galaxies that are too faint for Hubble's instruments to detect. Other explanations could include rogue stars stripped off from their galaxies, or even the light scattered off the dust in our own galaxy, the Milky Way. There could also be some unaccounted-for contribution from the spacecraft.

In addition to the Webb, other missions may provide some insight on the COB, including the SPHEREx mission (Spectro-Photometer for the History of the Universe and Ices Explorer) which will survey the sky in optical, as well as near-infrared light to gather data on more than 300 million galaxies, as well as more than 100 million stars in our own galaxy.

Another Casualty of War

The war in Ukraine has claimed another victim – the September launch of the long-delayed Rosalind Franklin rover. The rover was the second part of the ExoMars mission, a joint venture of the European Space Agency and the Russian space agency Roscosmos.



Artist's concept of the European-built Rosalind Franklin rover (foreground) and Russian-built Kazachok landing platform (background). Credit: ESA/ATG medialab

The first part of the ExoMars mission, the Trace Gas Orbiter (TGO) spacecraft, was launched successfully in 2016. Its mission is to search for evidence of methane and other trace atmospheric gases that could be signatures of active biological or geological processes on Mars. The orbiter also serves as a relay for the majority of data from NASA's Curiosity and Perseverance rovers, as well as the Insight lander.

The launch of the Rosalind Franklin rover was originally intended to follow TGO in 2018, the next opposition (an alignment that occurs every 26 months), but both the rover and the Russian lander ran into developmental delays. The 2020 launch date was delayed again to 2022, after experiencing parachute failures during drop tests (experts at NASA's Jet Propulsion Laboratory in California provided assistance in tracing the problem, which turned out to be the way the parachutes were released from their containers and not the parachutes themselves).

In March 2022, the member states of the ESA formally voted to suspend the joint mission with Russia because of the war in Ukraine. The rover has now been placed in storage until a way can be found to deliver the astrobiology laboratory to the Martian surface (the Russians were also providing the launch vehicle along with the lander).

Full House



Photo Credit: NASA/Joel Kowsky

Not since 2009 have the two Apollo-era launch pads (39A and B) been occupied at the same time. The pads, located about 8,700 feet (2.7 km) apart last hosted the shuttles Atlantis and Endeavour in May 2009, with Endeavour on standby for Atlantis' servicing mission to the Hubble Space Telescope.

In April, NASA moved their Space Launch System to an upgraded pad 39B (on the right in the photo) for a countdown dress rehearsal of their Artemis 1 unmanned circumlunar mission. NASA had leased pad 39A to SpaceX in 2014. The company has been launching its Falcon 9 and Falcon Heavy rockets from the pad since 2017. It is also the complex that SpaceX uses to launch its commercial crew missions to the International Space Station (ISS) for NASA, and more recently, for private companies such as Axiom.

In early April, SpaceX raised a Falcon 9 booster on pad 39A (on the left in the photo) for the first commercial all-private crew flight to the ISS. Mounted on top was SpaceX's Dragon Endeavour spacecraft (partly named in honor of the retired space shuttle) that would carry the four private astronauts, or "space tourists," to the station. The entire stack was 215 feet (65 meters) tall.

The Axiom Mission 1 was launched on April 8. NASA has since moved its 322 feet (98 meters) tall moon rocket back to the Vehicle Assembly Building to address several hardware problems discovered during the dress rehearsal.

Perseverance Arrives at the Delta



Aeolian bedforms (sand dunes) in front of the delta

Leading edge of the river delta, captured by one of the rover's mast-mounted cameras on Sol 406 of the mission (April 11, 2022) Credits: NASA/JPL-Caltech/ASU/MSSS

The science objectives of NASA's Perseverance Mars rover include the search for signs of ancient microbial life and the collection of rock and soil samples that might have preserved those biosignatures for retrieval by a future mission. After almost a year spent investigating rock formations around its landing site, and collecting eight rock samples, the rover has made its way to the front of the ancient river delta breaching the west wall of Jezero crater.

The delta formed billions of years ago from the buildup of sediment at the mouth of an ancient river as it emptied into a lake that once filled the crater. Scientists believe that the delta is an ideal location to begin their search with the best chance of finding the preserved remnants of ancient microbial life. The rover is currently assessing its options for eventually climbing up onto the top of the delta, which rises about 130 feet (40 meters) above the crater floor.

The current plan (called the "Delta Front Campaign") is for Perseverance to acquire rock samples as it climbs the delta front and then to take additional samples on its way back down. Eight samples are expected to be collected in the science campaign. Once back down on the crater floor, the rover will climb back up to begin the "Delta Top Campaign."

Hubble Portrait

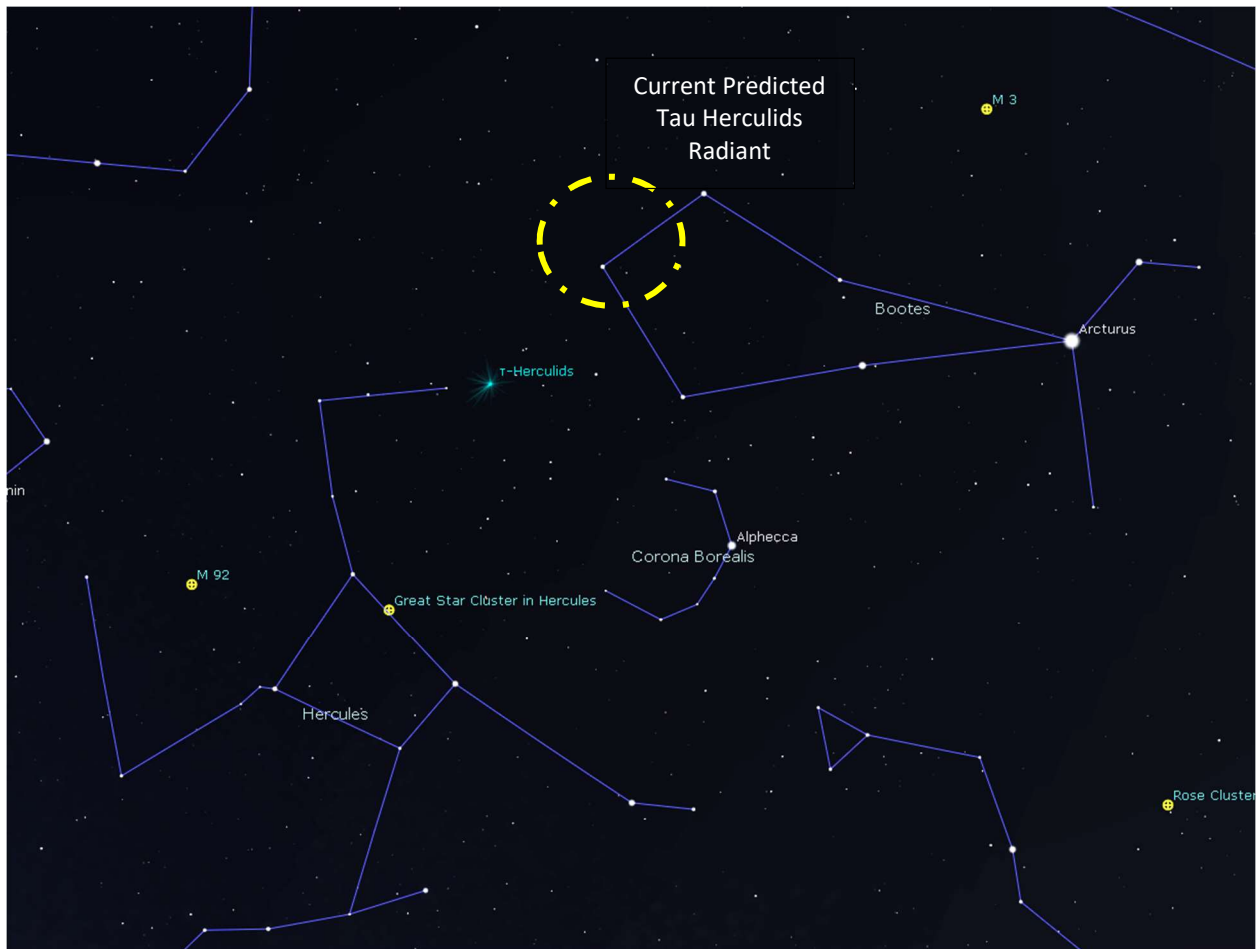


NGC 4571 Image credit: ESA/Hubble & NASA, J. Lee and the PHANGS-HST Team

NASA/ESA Hubble Space Telescope's Wide Field Camera 3 has delivered a stunning portrait of a spiral galaxy, NGC 4571. The galaxy, located in the constellation Coma Berenices, lies approximately 60 million light years away. It is just one of more than a thousand galaxies in the Virgo cluster.

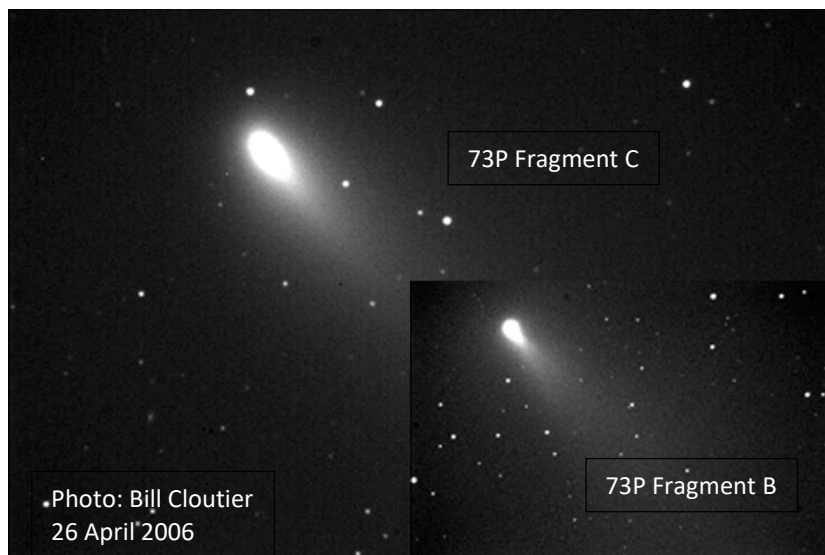
The image comes from a collaborative program of the Hubble and the Atacama Large Millimeter/submillimeter Array (ALMA) focused on star formation. ALMA is comprised of 66 high-precision antennas located high in the Chilean Andes. The array is sensitive to wavelengths between infrared and radio waves, allowing ALMA to detect clouds of cool interstellar dust (potential star-forming regions). Combined with Hubble's observations at ultraviolet wavelengths, astronomers are able to pinpoint the locations of hot, luminous, newly formed stars.

Meteor Shower Alert



In 1995, periodic comet 73P/Schwassmann-Wachmann, began to fragment with the main comet (fragment C) giving rise to two new fragments, A and B. By 2006, the breakup had produced more than 68 individual pieces.

Discovered in 1930, the comet orbits the sun every 5.4 years. As the individual pieces deconstruct, they leave behind a stream of ice and dust.



On the night of May 30-31, 2022, Earth passes through a particularly dense patch which the comet left behind in the years 1995, 1897 and 1892. This could spark a brief-but-intense meteor display. The radiant (the point in the sky from which the meteors appear to radiate) has drifted from its 1930 location. The current forecast is for peak activity around 1 AM on the 31st. With the Moon absent from the sky, watch for the slow-moving meteors about 45° from the radiant.

Apollo 10

Apollo 10 was the second mission to orbit the Moon (Apollo 8 being the first) and the first lunar mission to include the Lunar Module (LM). The Saturn V rocket, carrying the Command Module (CM) named Charlie Brown and LM, named Snoopy, was launched on May 18, 1969.



The Apollo 10 Saturn V and the mobile launch platform atop the crawler-transporter

Credit: NASA

Astronauts Thomas Stafford and Eugene Cernan flew the LM to within 47,000 feet (14,326 meters) of the lunar surface. The LM made two passes over the designated Apollo 11 landing site before jettisoning of the LM's descent stage (in preparation for the rendezvous with the CM). At that time, the ascent stage began to wildly gyrate and for three harrowing minutes, the spacecraft went into a near-fatal roll before Stafford could gain manual control. The cause was eventually traced to a switch being in the wrong position.

Public Astronomy



Photo: Bill Cloutier

Eighty-five years ago, on May 14, 1935, the Griffith Observatory opened to the public and its ownership transferred to the City of Los Angeles. Located on the southern slope of Mount Hollywood in Griffith Park, the public facility is operated by the city's Department of Recreation and Parks, and has welcomed over 76 million visitors since opening.

A public observatory was the brainchild of Griffith J. Griffith, a Welsh immigrant who made his fortune in Mexican silver mines and California real estate. In 1896, he purchased and donated 3,015 acres to the city for a public park after visiting grand open spaces in Europe. In 1912, after a visit to the Mount Wilson observatory, Griffith offered the city \$100,000 for a public observatory to be built on Mount Hollywood in Griffith Park. Griffith was quoted as saying "Man's sense of values ought to be revised. If all mankind could look through that telescope, it would change the world!"

Unfortunately, Griffith would not live to see his vision realized. Mired in political debate, work on the observatory didn't begin until 1933. However, guided by leading astronomers and scientists of the day, including astronomer George Ellery Hale, physicists Edward Kurth and Rudolph Langer, Adler Planetarium Director Philip Fox and Russell Porter, leader of the amateur telescope making movement, an observatory was constructed and dedicated two years later. The facility also included a planetarium. The planetarium was only the third of its kind in the United States; the technology was not even invented until four years after Griffith's death.

The Griffith Observatory is visible from many parts of Los Angeles, being located at an elevation of 1,134 feet above sea level. It is one of the most popular attractions in Southern California.

Space Shuttle History

The space shuttle Endeavour first arrived at the Kennedy Space Center on May 7, 1991 as a replacement for the lost Challenger. It was built out of spare parts from the construction of the Atlantis orbiter. Endeavour was first launched (STS-49) a year later on May 7, 1992. The orbiter's name was selected through a national competition among students and was named after the ship commanded by British explorer James Cook in his exploration of the South Pacific in 1768-71. Cook, among other accomplishments, observed the transit of the Sun by Venus from Tahiti in June 1769.

Endeavour flew its 25th and final mission (STS-134) in May 2011 (the next to last shuttle flight). Commander Mark Kelly was the last astronaut to disembark from the shuttle at the conclusion of the mission. In September 2012, the shuttle was flown to Los Angeles on top of a Boeing 747 for permanent display at the California Science Center. Endeavour is currently in temporary storage at the museum and will be displayed in a launch configuration (vertical) once construction of a new exhibition center is complete.

In May 2015, the Science Center announced that they had acquired the only flight-qualified external tank in existence. The tank had been built in 2000 for the Columbia shuttle but never flew (it was replaced by a lighter version before it was assigned to a flight). The External Tank (ET-94) is 28 feet in diameter, 154 feet long and weighs approximately 65,000 pounds.

The external tank left NASA's Michoud Assembly Facility in Louisiana for California on April 12, 2016. Traveling by barge, the tank passed through the Panama Canal and arrived in Marina del

Rey in late May. The tank was moved through the streets of Los Angeles to the Science Center following the route previously taken by Endeavour.

The Science Center has also acquired a pair of flight-worthy solid rocket boosters for the display. The 149-foot-tall (45 meter) solid rocket boosters were donated by Orbital ATK and NASA. The refurbished tank will be lifted into a vertical configuration to form the structural support for the Endeavour orbiter and the twin solid rockets for display in Samuel Oschin Air and Space Center, a 200,000 square foot exhibition center being added to the Science Center's main building.

May History



Vehicle Assembly Building
Photo: Bill Cloutier

On May 25, 1961, President Kennedy, in an address before a joint session of Congress, set forth a challenge to the American people: “I believe this nation should commit itself, before this decade is out, to landing a man on the Moon and returning him safely to the earth.” With what started out as an attempt to reverse the political setbacks in Laos, the Congo, the Bay of Pigs in Cuba, and as a response to the first flight into space by cosmonaut Yuri Gagarin, Kennedy’s speech set the gears of a technological revolution into motion. The post-Sputnik world of the 1960’s would see two great nations compete to control the “high ground,” the new frontier in the Cold War.

Lost in the political posturing and often overlooked is that, in less than 10 years, on May 20, 1969, the 456-foot-tall doors on the Vehicle Assembly Building at the Kennedy Space Center opened to reveal AS506, the official designation of the Saturn V rocket that would carry Apollo 11 to the moon. More than 20,000 private firms and hundreds of thousands of workers participated in this program, for a fraction of the cost of the Vietnam War. Not only did the United States reach the Moon, it built a national infrastructure of technology, manufacturing and education that has not been rivaled.

Final Servicing Mission

On May 11, 2009, the space shuttle Atlantis lifted off from Pad 29A at the Kennedy Space Center for its first visit to the Hubble Space Telescope and the telescope’s last servicing mission. Atlantis ferried two new instruments to the telescope - the Cosmic Origins Spectrograph and the Wide Field Camera 3. The Atlantis crew repaired the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS), replaced a Fine Guidance Sensor, six gyroscopes, and batteries. A new science computer was installed along with new insulation on three electronic bays. A soft-capture mechanism was added to the telescope’s base to facilitate its de-orbiting at its end of operational life.



The space shuttle Atlantis, on Pad 39A at the Kennedy Space Center, being readied for the final Hubble Space Telescope servicing mission (STS-125), May 2009

Photo: Bill Cloutier

The Atlantis crew included three astronauts that had visited Hubble on previous repair missions - Scott Altman (STS-109), John Grunsfeld, (STS-103 and STS-109) and Mike Massimino (STS-109).

Construction began on NASA's fourth space shuttle in 1980 and, with lessons-learned from the construction and testing of the Enterprise, Columbia and Challenger, was completed with half the effort spent on the Columbia. Atlantis is named for a two-masted sailing ship that operated for the Woods Hole Oceanographic Institute in Massachusetts from 1930 to 1966. The shuttle was delivered to the Kennedy Space Center on April 9, 1985. Six months later, she carried a classified payload into orbit for the Department of Defense (STS-51J). Among Atlantis' many accomplishments were: flying the first mission to the Russian space station (Mir), providing on-orbit launch capabilities for the Magellan (Venus) and Galileo (Jupiter) planetary probes as well as the Compton Gamma Ray Observatory, delivering the U.S. laboratory module Destiny, Joint Airlock Quest and multiple sections of the International Space Station's Integrated Truss structure.

May Showers

The *Eta Aquarids* meteor shower peaks in the early mornings of the 5th and 6th. The dust producing the shooting stars is from *Comet Halley*. As with all meteor showers, the Aquarids are named for the constellation (Aquarius) from which they appear to radiate. Typically, you can expect to see up to 20 meteors per hour. An early setting, waxing crescent moon should not interfere with viewing the shower this year.

Sunrise and Sunset (from New Milford, CT)

	<u>Sunrise</u>	<u>Sunset</u>
May 1 st (EDT)	05:50	19:51
May 15 th	05:34	20:06
May 31 st	05:22	20:20

May Nights

For those who do their stargazing early in the evening, a myriad of spectacular objects appear out of the twilight, winking into view as the Earth turns away from the Sun. Leo dominates the southwestern sky with its reverse question mark arrangement of stars, punctuated by the star Regulus, forming the front of the lion, and a triangular arrangement of stars forming the back or tail of the creature. To the west of Leo is an open star cluster called the Beehive (M44) in the constellation Cancer. On a dark night it can be seen with the naked eye. East of Leo, towards the constellation Boötes is the globular cluster M3. Boötes is easily identified by its bright star Arcturus. Follow the arc in the handle of the Big Dipper to find Arcturus, at the base of the kite-shaped constellation. M3 is located further away than the center of our galaxy, the Milky Way, and is one of the many outstanding globular clusters that will grace the late spring and summer skies.

Astronomical and Historical Events

- 1st Asteroid *10 Hygiea* closest approach to Earth (1.799 AU)
- 1st Kuiper Belt Object 2014 FC69 at Opposition (84.794 AU)

Astronomical and Historical Events (continued)

- 1st History: Goddard Space Flight Center established (1959)
- 1st History: discovery of Saturn's moon *Daphnis* by the Cassini spacecraft (2005)
- 1st History: discovery of the Mars meteorite *Dar al Gani 476* (1998)
- 1st History: discovery of Neptune's moon *Nereid* by Gerard Kuiper (1949)
- 2nd Atira Asteroid 418265 (2008 EA32) closest approach to Earth (0.597 AU)
- 2nd Atira Asteroid 2019 AQ3 closest approach to Earth (0.632 AU)
- 2nd Kuiper Belt Object *184314 Mbabamwanawaresa* at Opposition (39.461 AU)
- 2nd History: discovery of the first binary star (Xi Ursae Majoris) by William Herschel (1780)
- 4th Star Wars Day
- 4th Aten Asteroid 2017 HG1 near-Earth flyby (0.047 AU)
- 4th Amor Asteroid *5370 Taranis* closest approach to Earth (2.460 AU)
- 4th History: launch of the AQUA satellite to study precipitation, evaporation, and the cycling of Earth's water (2002)
- 4th History: launch of the Magellan/Venus radar mapping spacecraft and attached Inertial Upper Stage from the space shuttle Atlantis (STS-30) (1989)
- 4th History: launch of Lunar Orbiter 4 for photographic evaluation of Apollo and Surveyor landing sites (1967)
- 5th *Eta Aquarids* meteor shower peak (best viewing: early morning on the 5th and 6th)
- 5th Moon at apogee (furthest distance from Earth)
- 5th Centaur Object *944 Hidalgo* at Opposition (6.898 AU)
- 5th History: launch of NASA's InSight spacecraft (Mars lander) from the Vandenberg Air Force Base, California (2018)
- 5th History: launch of Freedom 7 and astronaut Alan Shepard aboard a Mercury-Redstone rocket, first American in space (1961)
- 6th History: groundbreaking for the John J. McCarthy Observatory, a world-class observatory in New Milford, CT., with a mission to promote science literacy (2000)
- 7th Comet *8P/Tuttle* closest approach to Earth (2.476 AU)
- 7th Amor Asteroid *2059 Baboquivari* closest approach to Earth (2.983 AU)
- 8th First Quarter Moon
- 9th Aten Asteroid 467460 (2006 JF42) near-Earth flyby (0.038 AU)
- 9th Kuiper Belt Object *42355 Typhon* at Opposition (23.067 AU)
- 9th History: launch of MUSES-C (Hayabusa), Japanese sample return mission to asteroid *Itokawa* (2003)
- 9th History: first Earth-based laser aimed at the Moon: crater Albategnius (1962)
- 9th History: launch of first production model of the Project Mercury capsule from Wallops Island, Virginia to test the escape system (1960)
- 10th History: OSIRIS-REx departs asteroid Bennu for Earth (2021)
- 10th History: President Truman signs Public Law 507, creating the National Science Foundation (1950)
- 10th History: Estherville Meteorite Shower: a 455-pound meteorite fell to earth in Emmet County, just north of Estherville, Iowa, where it buried itself 15 feet in the ground - largest meteorite known to have fallen in North America (1879)
- 11th Apollo Asteroid 2019 JE near-Earth flyby (0.013 AU)
- 11th Apollo Asteroid *471926 Jormungandr* closest approach to Earth (0.806 AU)
- 11th Asteroid *21 Lutetia* closest approach to Earth (1.485 AU)
- 11th Centaur Object *471143 Dzewanna* at Opposition (34.154 AU)

Astronomical and Historical Events (continued)

- 11th History: launch of the space shuttle Atlantis (STS-125), final Hubble Space Telescope servicing mission (2009)
- 12th Atira Asteroid 2013 TQ5 closest approach to Earth (0.376 AU)
- 12th Asteroid 87 *Sylvia* (2 Moons) closest approach to Earth (1.557 AU)
- 12th Centaur Object 144908 (2004 YH32) at Opposition (9.960 AU)
- 12th History: first planetarium (Adler Planetarium in Chicago) opens in United States (1930)
- 13th Kuiper Belt Object 2010 FX86 at Opposition (44.930 AU)
- 13th History: launch of first Project Bumper rocket from White Sands, NM; the two stage rocket was a combination of a German V-2 and American WAC Corporal rocket (1948)
- 14th **Second Saturday Stars - Open House at McCarthy Observatory**
- 14th History: Griffith Observatory, one of the first institutions in the U.S. dedicated to public science, opens in Los Angeles (1935)
- 14th History: launch of the Herschel infrared telescope and the Planck microwave observatory (2009)
- 14th History: launch of Skylab, the United States' first space station (1973)
- 14th History: the American Interplanetary Society (later renamed the American Rocket Society) launches its first liquid fueled (liquid oxygen and gasoline) rocket from Staten Island, N.Y. (1933)
- 14th History: German Society for Space Travel (Verein für Raumschiffahrt or VfR) launches the Repulsor-1, a liquid fueled (liquid oxygen and gasoline) rocket (1931)
- 14th History: Orgueil meteorite shower: large carbonaceous chondrite that disintegrated and fell in fragments near the French town of Orgueil; presence of organics renewed the debate on spontaneous generation as the origin of life; fragments analyzed by the French chemist Louise Pasteur for indigenous microorganisms (1864)
- 15th Apollo Asteroid 2012 UX68 near-Earth flyby (0.007 AU)
- 15th Apollo Asteroid 388945 (2008 TZ3) near-Earth flyby (0.038 AU)
- 15th Kuiper Belt Object 65407 (2002 RP120) at Opposition (34.408 AU)
- 15th Kuiper Belt Object 53311 *Deucalion* at Opposition (41.542 AU)
- 15th History: discovery of Pluto's moons *Nix* and *Hydra* by Hal Weaver, et al's (2005)
- 15th History: sixth docking of a space shuttle (Atlantis) with Russian space station Mir (1997)
- 15th History: launch of Faith 7 and astronaut Gordon Cooper aboard a Mercury-Atlas rocket, final Mercury mission (1963)
- 15th History: Soviet Union launches Sputnik IV containing a self-sustaining biological cabin and dummy astronaut (1960)
- 16th Full Moon (Full Flower Moon)
- 16th Total Lunar Eclipse
- 16th Apollo Asteroid 3200 *Phaethon* closest approach to Earth (0.873 AU)
- 16th Kuiper Belt Object 90568 (2004 GV9) at Opposition (38.767 AU)
- 16th History: launch of the space shuttle Endeavor to the International Space Station on its final mission (2011)
- 16th History: Soviet spacecraft Venera 5 returns 53 minutes of data while descending by parachute through the atmosphere of Venus and before impacting the surface (1969)
- 17th Moon at perigee (closest distance from Earth)
- 17th Apollo Asteroid 2013 UX near-Earth flyby (0.043 AU)
- 17th Amor Asteroid 719 *Albert* closest approach to Earth (1.613 AU)

Astronomical and Historical Events (continued)

- 17th History: Soviet spacecraft Venera 6 returns 51 minutes of data while descending by parachute through the atmosphere of Venus and before impacting the surface (1969)
- 17th History: discovery of Jupiter's cloud belts by Italian Jesuit, astronomer, and physicist Niccolo Zucchi (1630)
- 18th Atira Asteroid 2010 XB11 closest approach to Earth (0.679 AU)
- 18th Amor Asteroid 5797 *Bivoj* closest approach to Earth (1.304 AU)
- 18th Centaur Object 65489 *Ceto* at Opposition (41.236 AU)
- 18th History: launch of Apollo 10 with astronauts John Young, Tom Stafford and Gene Cernan; the lunar module Snoopy was flown within 50,000 feet of the lunar surface while the command module Charlie Brown orbited the Moon (1969)
- 19th Apollo Asteroid 2006 QV89 closest approach to Earth (1.830 AU)
- 19th Scheduled launch of Boeing's CST-100 Starliner, an unmanned test flight to the International Space Station from the Cape Canaveral Air Force Station, Florida
- 19th History: launch of the Mars 2 orbiter/lander (which subsequently crashed) (1971)
- 19th History: launch of the first Army Hermes A-1 rocket from White Sands, NM (1950)
- 19th History: oldest recorded meteorite fall, a 472-gram, ordinary chondrite, falls in Nogata, Japan (861 AD)
- 20th History: launch of the Japanese Venus Climate Orbiter Akatsuki or Planet-C spacecraft and the Ikaros solar sail (2010)
- 20th History: launch of the Pioneer Venus 1 spacecraft (1978)
- 21st Apollo Asteroid 162173 *Ryugu* closest approach to Earth (1.607 AU)
- 21st Kuiper Belt Object 2015 KH162 at Opposition (59.800 AU)
- 22nd Last Quarter Moon
- 22nd Comet C/2021 A1 (*Leonard*) closest approach to Earth (1.647 AU)
- 22nd Apollo Asteroid 2101 *Adonis* closest approach to Earth (1.935 AU)
- 22nd History: launch of the GRACE Follow-On spacecraft from the Vandenberg Air Force Base, California. The tandem satellites tracking Earth's water movement and changes in sea level.
- 22nd History: launch (and recovery) of monkeys Patricia and Mike on an Aerobee rocket, reaching a record altitude of 30 miles (1952)
- 23rd Atira Asteroid 434326 (2004 JG6) closest approach to Earth (1.138 AU)
- 23rd Apollo Asteroid 4341 *Poseidon* closest approach to Earth (1.032 AU)
- 23rd Asteroid 52246 *Donaldjohanson* closest approach to Earth (1.605 AU)
- 23rd Kuiper Belt Object 2015 BP519 at Opposition (50.704 AU)
- 24th History: discovery of Neptune's moon Larissa by Stephen Synnott, Harold Reitsema, and David Tholen (1981)
- 24th History: launch of Aurora 7 and astronaut Scott Carpenter aboard a Mercury-Atlas rocket; second American to orbit Earth (1962)
- 24th History: launch of Midas 2; first Experimental Infrared Surveillance Satellite (1960)
- 24th History: Russian civil engineer Ivan Yarkovsky born. Proposed idea that heat radiated from rotating bodies, such as asteroids, would generate a small force which over time could change the orbit (1844)
- 25th Towel Day - Annual Tribute to Douglas Adam
- 25th Atira Asteroid 2021 PH27 Perihelion (0.133 AU)
- 25th History: Phoenix spacecraft lands in the Martian arctic (2008)

Astronomical and Historical Events (continued)

- 25th History: launch of first Skylab crew; astronauts Pete Conrad, Paul Weitz and Joseph Kerwin (1973)
- 25th History: President John F. Kennedy's Moon goal speech to Congress (1961)
- 25th History: science fiction writer and futurist Arthur C. Clark proposes communication satellites in geosynchronous orbit (1945)
- 25th History: first recorded perihelion passage of comet Halley by Chinese astronomers (240 BC)
- 26th History: launch of the first "Navaho Missile," a pilotless aircraft consisting of a missile and a booster; program goal was to determine the feasibility of an intercontinental missile (1948)
- 27th Apollo Asteroid 7335 (1989 JA) near-Earth flyby (0.027 AU)
- 27th Amor Asteroid 3551 *Verenia* closest approach to Earth (1.453 AU)
- 28th Mars passes 0.6° from Jupiter
- 28th History: launch of Mars 3 (USSR) lander and rover; lander became the first spacecraft to attain soft landing on Mars, although transmissions ceased after 15 seconds (1971)
- 28th History: launch of an Army Jupiter missile carrying two primates (Able and Baker) to an altitude of 300 miles; monkeys survived the flight (1959)
- 28th History: Frank Drake born - radio astronomer devised the "Drake Equation" as an attempt to estimate the number of worlds in our galaxy that might harbor intelligent life (1930)
- 29th Amor Asteroid 3122 *Florence* (2 Moons) closest approach to Earth (1.597 AU)
- 29th History: Solar Eclipse observations (specifically, positions of stars in the vicinity of the Sun) used to confirm Einstein's General Theory of Relativity (1919)
- 29th History: launch of Luna 22 (USSR), lunar orbiter mission that included imaging as well as studying the Moon's magnetic field, the composition of lunar surface rocks, and the gravitational field (1974)
- 29th History: measurements during solar eclipse agree with predictions based on Einstein's General Relativity theory (1919)
- 30th New Moon
- 30th Apollo Asteroid 137052 *Tjelvar* closest approach to Earth (0.759 AU)
- 30th History: launch of SpaceX's Crew Dragon with astronauts Doug Hurley and Bob Behnken to the International Space Station from the Kennedy Space Center. Designated Demo 2, it was the first launch of the spacecraft with astronauts aboard. (2020)
- 30th History: launch of Mariner 9, Mars orbiter and first artificial satellite of Mars; mapped Martian surface and imaged moons *Phobos* and *Deimos* (1971)
- 30th History: launch of Surveyor 1, Moon lander; transmitted over 11,000 images from Oceanus Procellarum (1966)
- 31st Apollo Asteroid 37655 *Illapa* closest approach to Earth (1.552 AU)
- 31st Asteroid 55 *Pandora* closest approach to Earth (1.973 AU)
- 31st History: European Space Agency's birthday (1975)

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 ($\frac{1}{2}^\circ$), 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

- www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other manmade objects.

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

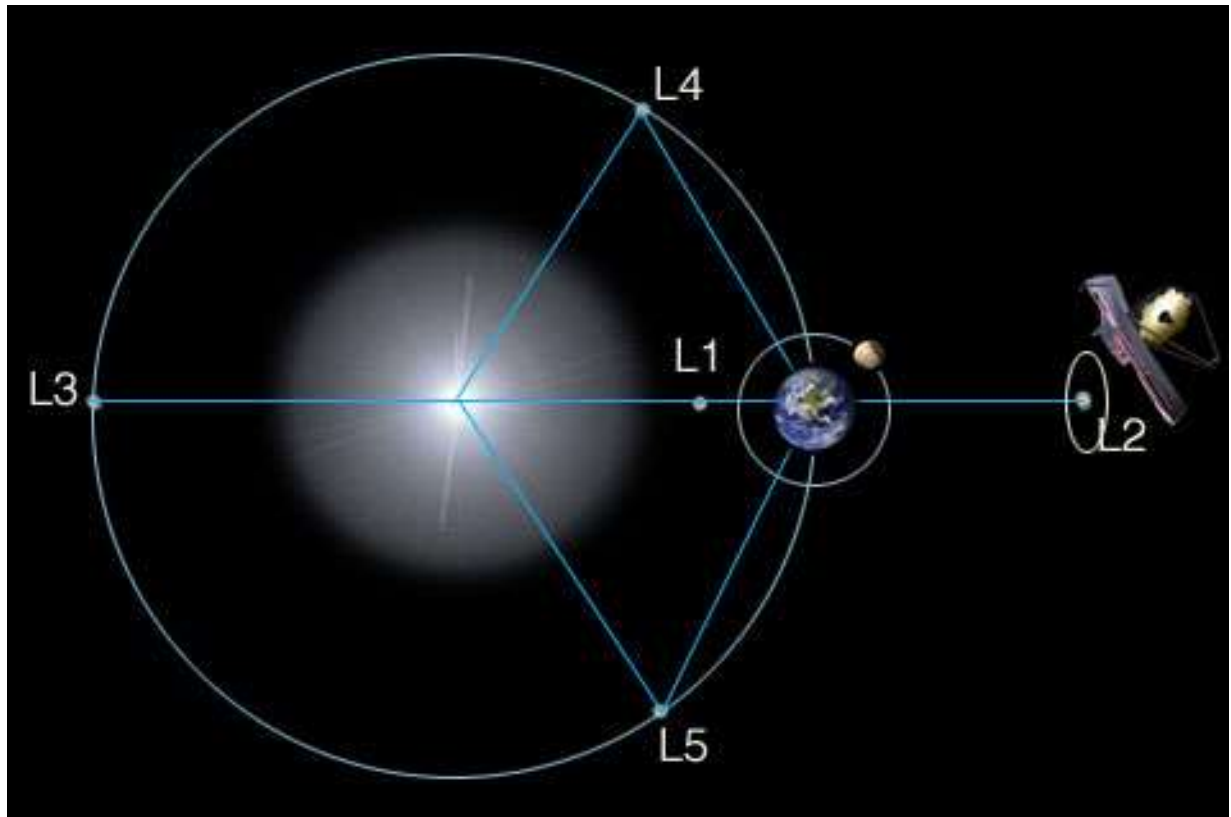
- Vital Signs of the Planet: <https://climate.nasa.gov/>

Mars – Mission Websites

- Mars 2020 (Perseverance rover): <https://mars.nasa.gov/mars2020/>
- Mars Helicopter (Ingenuity): <https://mars.nasa.gov/technology/helicopter/>
- Jezero Crater map: <https://mars.nasa.gov/mars2020/mission/where-is-the-rover/>
- Mars Science Laboratory (Curiosity rover): <https://mars.nasa.gov/msl/home/>
- Mars InSight (lander): <https://mars.nasa.gov/insight/>

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and location of the Webb telescope) is located 1 million miles (1.5 million km) beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

- <https://webb.nasa.gov/index.html>

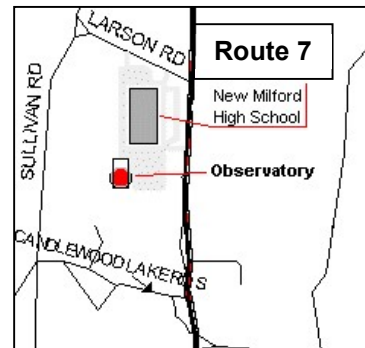
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