Galactic Observer

John J. McCarthy Observatory

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Wheel of Destiny?

See page 19 for more information

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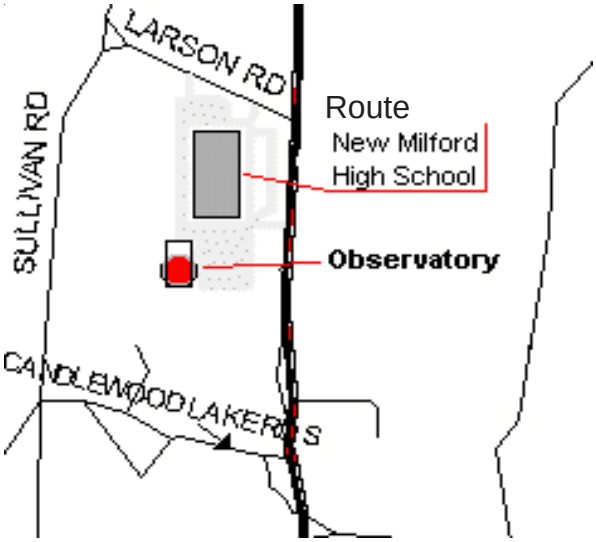


In This Issue

January Astronomy Calendar and Space Exploration Almanac

Photo: Marc Polansky

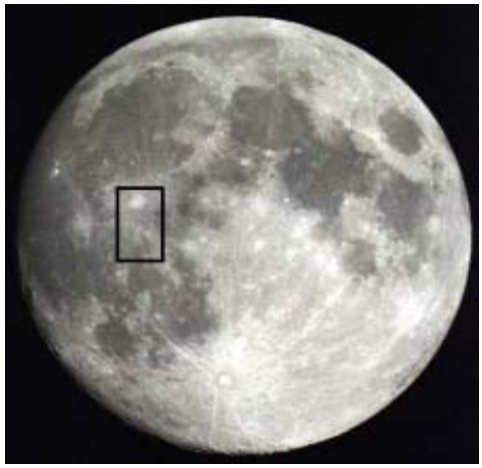
On December 16th, Comet 46P/Wirtanen passed within 7 million miles (11.5 million km) of the Earth. The comet's core or nucleus is a little more than ¾ mile across (1.2 km), so small that it doesn't produce enough gas and dust for a spectacular celestial show. It was, however, an easy target for binoculars and small telescopes.

46P/Wirtanen is a short period comet (comets with orbital periods less than 200 years). Its 5.4 year orbit carries the dirty snowball almost out to the orbit of Jupiter at its furthest (5.1 Astronomical Units or AUs) and just beyond the orbit of Earth when closest to the Sun (1.05 AU). The comet has had two recent encounters with the planet Jupiter, in April 1972 and again in February 1984, which modified its orbit, pushing it about 50 million miles closer to the Sun and closer to the orbit of Earth.

The comet (one of three) was discovered by Carl Wirtanen in 1948 at the Lick Observatory in California. Its encounter with the Earth on the 16th was less than four days after making its closest approach to the Sun.

"Out the Window on Your Left"

It's been more than 46 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. 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).

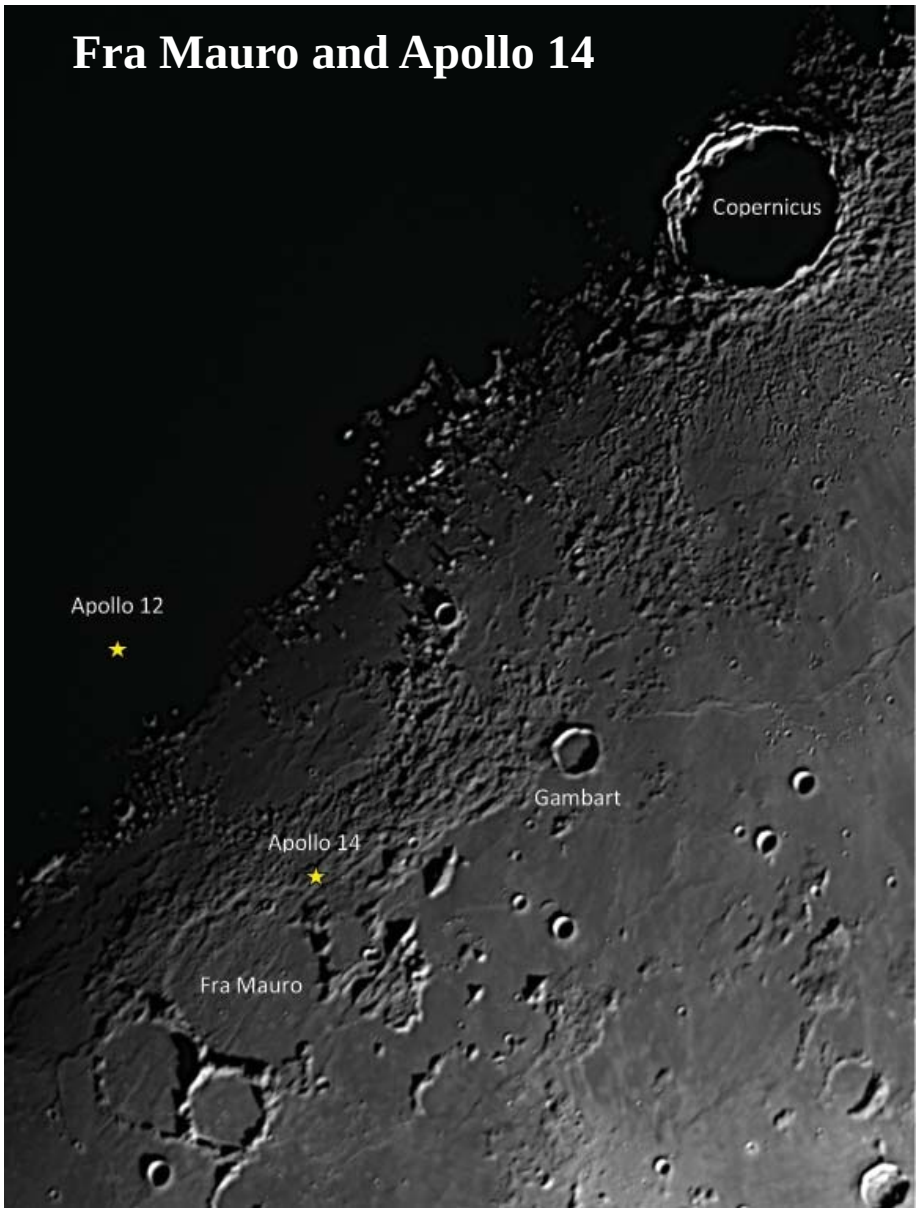


The Moon's Fra Maura Region

Apollo 14 was launched on January 31, 1971 at 4:03 pm EDT. Commanding the mission was Alan B. Shepard Jr., the only one of the original seven Mercury program astronauts to fly to the Moon. It was only Shepard's second flight after becoming the first American to reach space in May of 1961 with a 15 minute suborbital flight (he had been grounded for almost a decade with an inner ear ailment). Accompanying Shepard were Edgar Mitchell as Lunar Module Pilot and Stuart Roosa as Command Module Pilot.

The Apollo 14 landing site (originally the destination of the aborted Apollo 13 mission) is north of the Fra Mauro impact crater. Bright ray material from the Copernicus crater, approximately 225 miles (360 km) to the north, cover the site along with impact ejecta from the Imbrium Basin 310 miles or 500 km to the north. Nearby was Cone crater, a relatively young impact feature that penetrated the regolith.

The lunar lander, Antares, executed a pinpoint landing, approximately 87 feet from its target, and about 110 miles east of the Apollo 12 landing site, on February 5th. Shepard and Mitchell spent 33½ hours on the Moon, including almost 9½ hours exploring the surface in two separate excursions. During the second excursion, the two astronauts attempted to summit Cone crater, 300 feet (91 meters) above the landing site. The trek consumed more time and energy than anticipated (the astronauts were also dragging a wheeled cart with tools and samples up the hill) and mission control had the astronauts turn back before they were able to reach the rim. Recent analysis, using Lunar Reconnaissance Orbiter images, show the astronauts were less than 100 feet (30 meters) from the rim at turnaround.

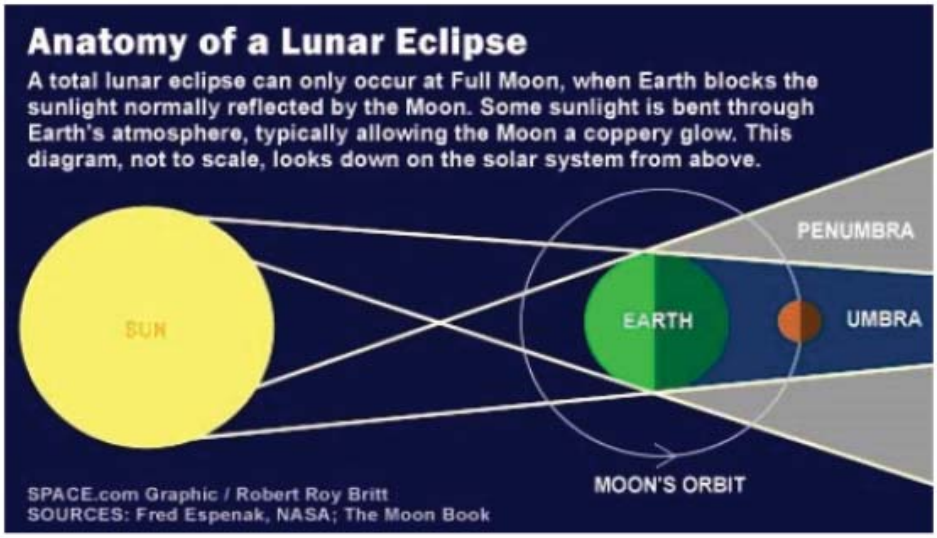


The crew of Apollo 14 gathered almost 110 pounds (43 kg) of rock. The samples of Imbrium Basin ejecta returned by Shepard and Mitchell were radiometrically dated to approximately 3.85 billion years ago, making it one of the youngest impact basins, possibly second youngest, to the Orientale Basin. Samples returned by the Apollo 12 astronauts had previously dated the Copernicus crater impact at 800 million years ago.

As the astronauts were ending their time out on the surface, Alan Shepard used a makeshift club to hit two golf balls.

Lunar Eclipse

On the evening of January 20th, the full Moon will 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 at the right 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 the 20th, the Moon will travel through the northern half of umbra. The eclipse will be visible (weather permitting) for observers in North America, with totality starting at 11:41 pm EDT and lasting 62 minutes. January's Full Moon will be one of the closest to the Earth in 2019 (222,043 miles or 357,344 km) and appear up to 14% larger than the average Full Moon. The next total lunar eclipse visible in the northeast U.S. will be in May 2021.



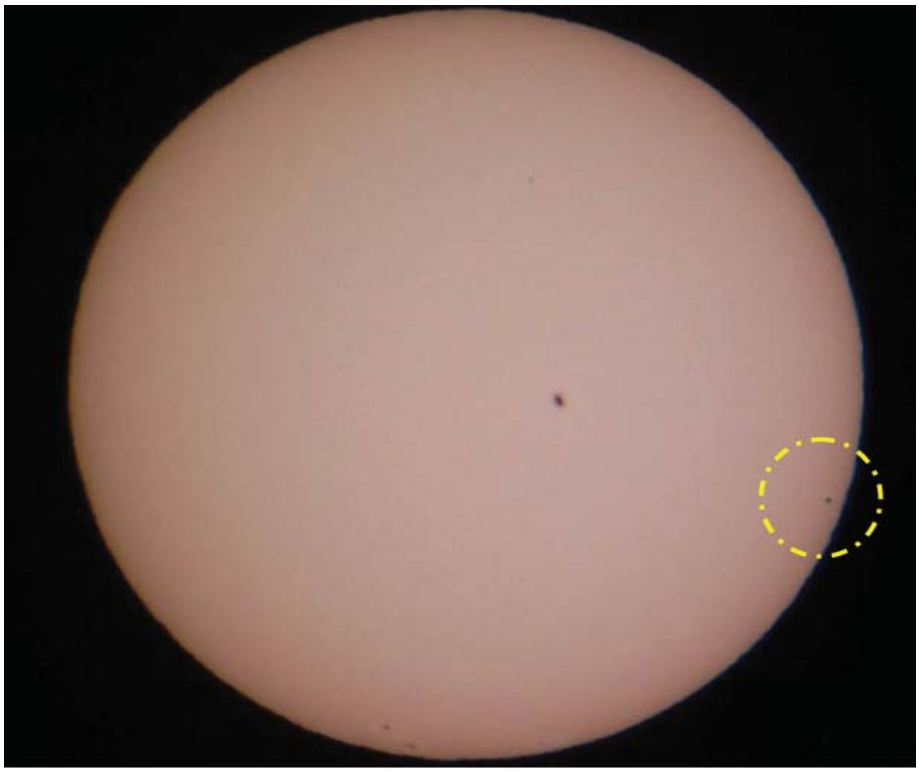
Total eclipse begins (Moon completely within the umbra) 11:41:17 pm EDT
Total eclipse ends (Moon begins to exit umbra) 12:43:16 am EDT

Planets in 2019

Mercury and Venus, being interior planets (closer to the Sun) can, on rare instances, be seen from Earth crossing the Sun's disk. A transit of the planet Mercury occurs, on average, 13 times each century (Venus transits are even rarer).

The next transit of Mercury will take place on November 11th. For watchers on the east coast, the entire transit will be visible (weather permitting). With the proper solar filters, observers will be able to see a small, dark spot traveling across the Sun's disk. The transit will begin around 7:30 EDT, about an hour after sunrise, and last approximately 5½ hours. The next transit of Mercury will not take place until 2032.

The outer planets return to the evening sky in the latter half of 2019, appearing at their



Early morning transit (or passage) of Mercury across the solar disk on May 07, 2003. Photo Credit: Dr. Parker Moreland

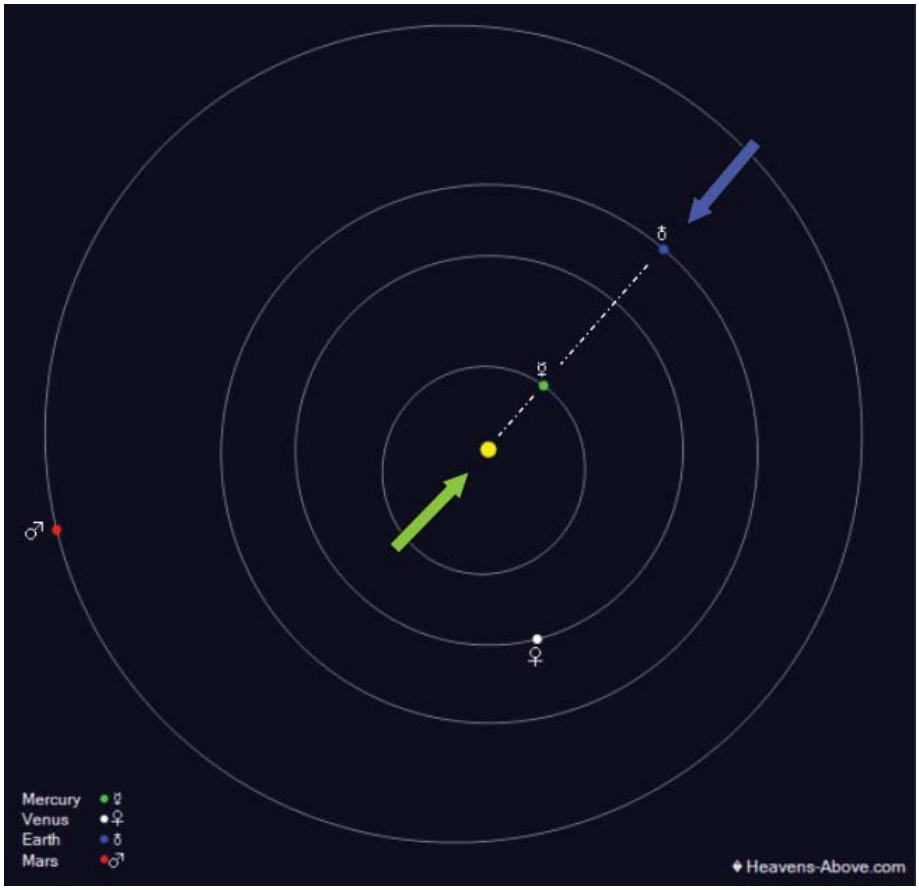
brightest when they are at or near Opposition (when the planet is opposite the Sun in our sky). Superior planets (located beyond the orbit of Earth) rise at sunset and are highest in our sky at midnight around the time of Opposition.

Jupiter reaches Opposition on June 10th, when the planet will be at its closest to Earth and therefore at its brightest. On average, the gas giant reaches Opposition every 399 days, about 33 days later each successive year. The gas giant can be found in the constellation Ophiuchus, the Serpent-Bearer. At a distance of 4.28 AU from Earth (approximately 400 million miles or 640 million km), Jupiter will shine at an apparent magnitude (maximum brightness) of -2.6.

Saturn reaches Opposition on July 9th. On average, the ringed planet reaches Opposition every 378 days, about 13 days later than the previous year each successive year. The gas giant can be found in the constellation Sagittarius, the Archer. At a distance of 9.03 AU from Earth (approximately 840 million miles or 1.351 billion km), Saturn will shine at an apparent magnitude (maximum brightness) of +0.0, considerably dimmer than Jupiter, which will be almost 11 times brighter at Opposition. The planet's rings will be tilted at an angle of +24°, slightly less open than in 2018 (at 26°), with the planet's north pole sunlit.

Neptune reaches Opposition on September 9th. The blue ice giant can be found in the constellation Aquarius, the Water Carrier, but at an apparent magnitude of +7.8, you will need binoculars or a telescope to even locate the eighth planet against the background stars. At its closest, Neptune will be a distant 28.94 AUs from the Earth (approximately 2.69 billion miles or 4.33 billion km).

Uranus reaches Opposition on October 27th. The first planet to be discovered with the telescope can be found in the constellation



Alignment of Mercury and Earth on November 11th

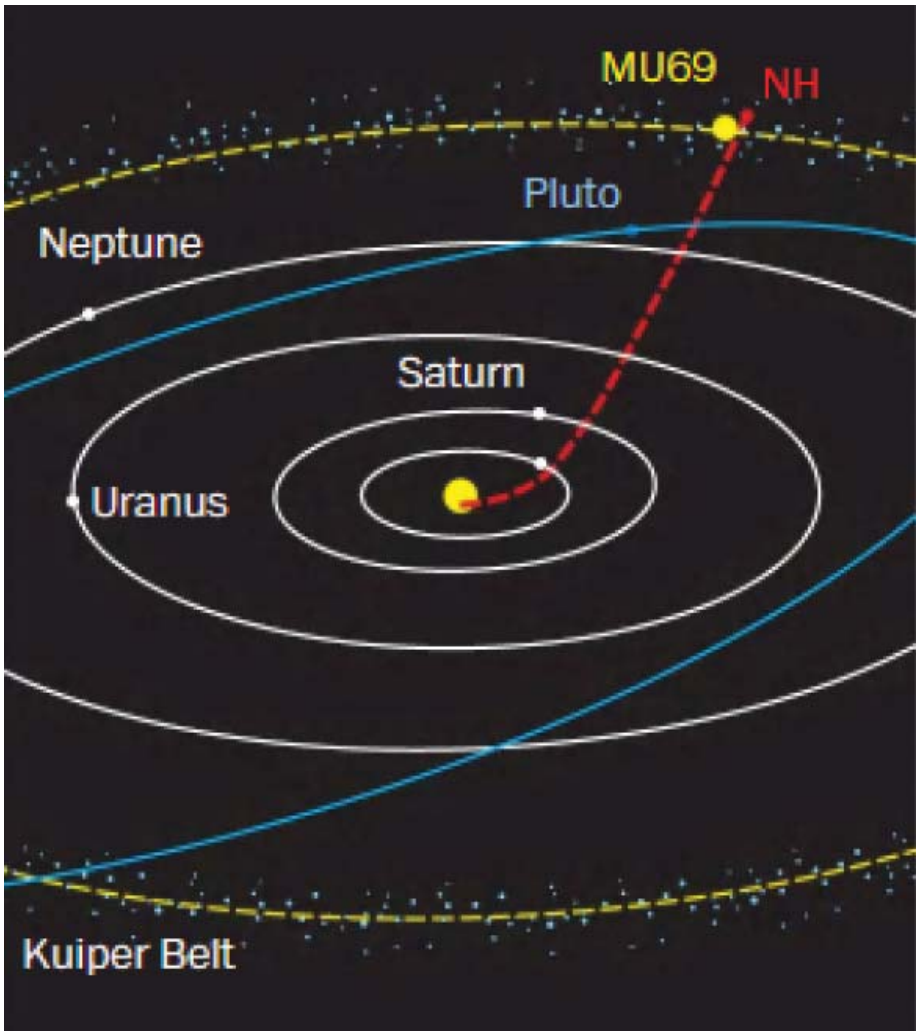
Aries, the Ram. At an apparent magnitude of +5.7, you will need perfect seeing conditions (dark, clear skies) to visually spot the seventh planet. Uranus will be almost a billion miles closer than Neptune, but still a distant 18.85 AUs from the Earth (approximately 1.75 billion miles or 2.82 billion km). Only with the aid of a telescope will you be able to see the blue-green disk of the bowled over planet.

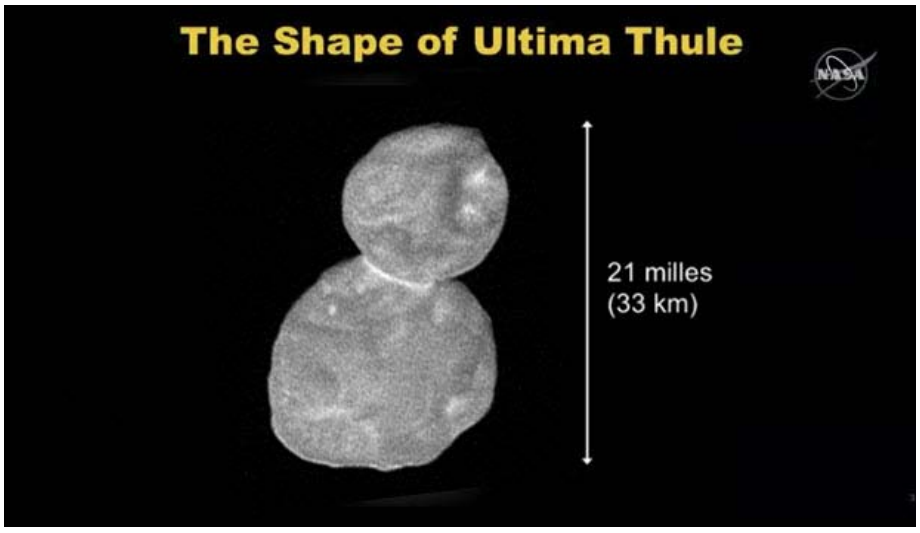
Ultima Thule

On New Year's Day, the New Horizons spacecraft cruised pass the tiny Kuiper Belt Object (KBO) 2014 MU69 (informally named Ultima Thule), orbiting nearly a billion miles (1.6 billion km) beyond the orbit of Pluto. The snowman-shaped KBO is roughly 21.7 miles (35 km) long and 9.3 miles (15 km) wide and takes almost 300 years to complete a circuit around the Sun. Scientists believe that the small rocky body may be a relic from the formation of the early solar system and, as such, relatively unchanged over the past 4.5 billion years.

The New Horizons' project team adjusted the spacecraft's trajectory on December 2nd, firing its thrusters for 105 seconds and changing the spacecraft's velocity by 2.2 miles per hour (1 mps). The course correction brought the spacecraft within 2,200 miles (3,500 km) of Ultima Thule. At that distance surface details as small as 230 feet (70 meters) across should be resolved. Close encounter occurred at 12:33 a.m. EST on January 1st.

Color images captured by the spacecraft's Multispectral Visible Imaging Camera show the KBO's surface to be reddish in color. The color is not uniform, with the area around the neck region showing very little color. Radio signals from the spacecraft now take more than six hours to reach Earth, at the speed of light. The approximately 7 gigabytes of data collected during the pass are expected to take up to 20 months to transmit.





Ultima Thule as captured by the spacecraft's Long-Range Reconnaissance Imager just 30 minutes before closest approach from a range of 18,000 miles (28,000 km). Image credit: NASA/JHUAPL/SwRI

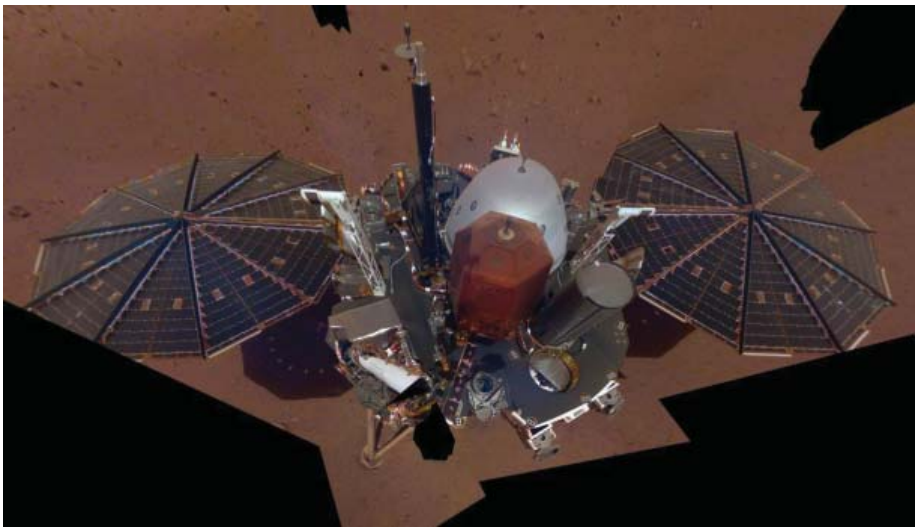
If you are a fan of the rock group Queen, guitarist, astrophysicist and contributing scientist Brian May released a new video on January 1st, with an original music score for the flyby. If the Voyager spacecraft can take along a Chuck Berry tune into interstellar space, why not a little rock music for the Kuiper Belt and Ultima Thule?

The Sandbox

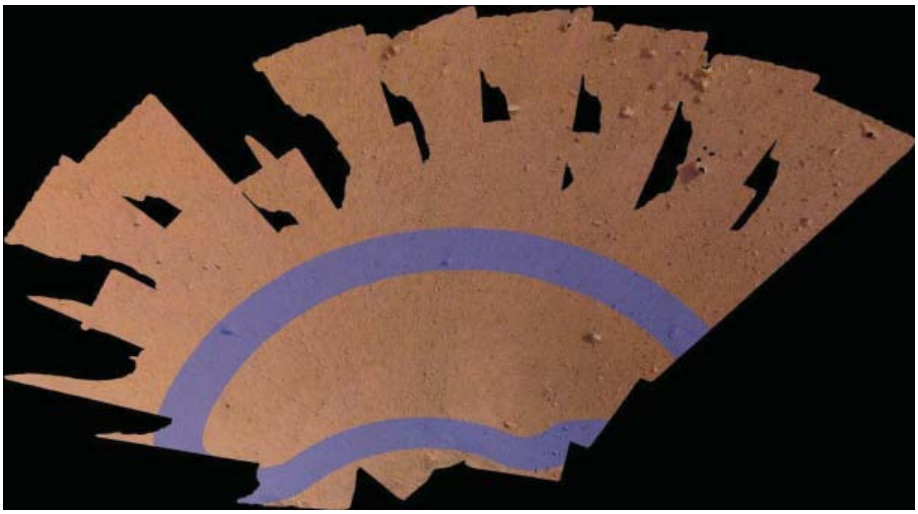
The InSight project team was looking for a landing site that was relatively level and boulder free. The ideal spot would also have the right soil consistency for the self-burrowing mole to reach its full range of approximately 16 feet (5 meters). The team had targeted Elysium Planitia, a flat, smooth plain near Mars' equator after an extensive orbital survey, but as the spacecraft neared Mars, it appeared to be heading for a less desirable area within the landing ellipse. On the day prior to landing, JPL engineers sent commands to the spacecraft that successfully adjusted the landing site by a few miles (kilometers). Based upon the initial assessment, the landing site is just about picture perfect.

Since landing, mission engineers have been testing InSight's instruments and spacecraft systems, ensuring that everything is in working order. The seismometer has been placed on the surface by the lander's robotic arm (first time a robotic arm has been used for staging equipment on another planet). It is now being calibrated for operation.

InSight's primary mission is scheduled for two Earth years, or one Mars year. The science from the lander's instruments will contribute to our understanding of the formation of other rocky and terrestrial planets in our solar system as well as around other stars.



InSight's first selfie on Mars. A composite of 11 separate images were captured by the lander's Instrument Deployment Camera mounted on its robotic arm. Shown in the photo are the lander's solar panels and deck, the seismometer (orange hexagon) before it was deployed, the wind and temperature shield (gray dome behind the seismometer), and the Heat Flow and Physical Properties Probe (HP3) burrowing device (black cylinder to the left of the dome). Credit: NASA/JPL-Caltech



A mosaic, comprised of 52 individual images that shows the area available (within the lavender boundary) for setting down the HP3 instrument and the seismometer. The bounded area is approximately 14 x 7 feet (4 x 2 meters). Credit: NASA/JPL-Caltech

Arrival

The NASA's Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft arrived at the asteroid Bennu on December 3rd after a 1.2 billion mile (2 billion km) journey. OSIRIS-REx is now stationed about 11.8 miles (19 km) from Bennu's surface and conducting a preliminary survey of the asteroid. The spacecraft will close within 4 miles (7 kilometers) of the rocky surface before entering orbit on December 31st.

In its short time on station, project scientists have developed

a preliminary estimate of the asteroid's density. At 75 pounds per cubic foot (1,200 kg/m3), the asteroid is akin to a pile of rubble, with possible interior caves and voids (average rock is about 188 pounds per cubic foot or 3,000 kg/m3).

Scientists expected that the primitive B-type asteroid would be rich in carbon and organic molecules, but the spacecraft's two spectrometers (the OSIRIS-REx Visible and Infrared Spectrometer (OVIRS) and the OSIRIS-REx Thermal Emission Spectrometer (OTES), have also discovered the presence of "hydroxyls," molecules that contain oxygen and hydrogen atoms bonded together. The hydroxyls are believed to be bound within clay minerals, suggesting that the asteroid's surface had been exposed to water at one time. While too small to have had liquid water pool on its surface, the finding suggests that Bennu's parent body may have been wet in the distant past.

The asteroid Bennu from a distance of 15 miles (24 km). For scale, the large boulder near the south pole (right side) is 164 feet high and 180 feet wide (50 meters by 55 meters).
Credits: NASA/Goddard/University of Arizona

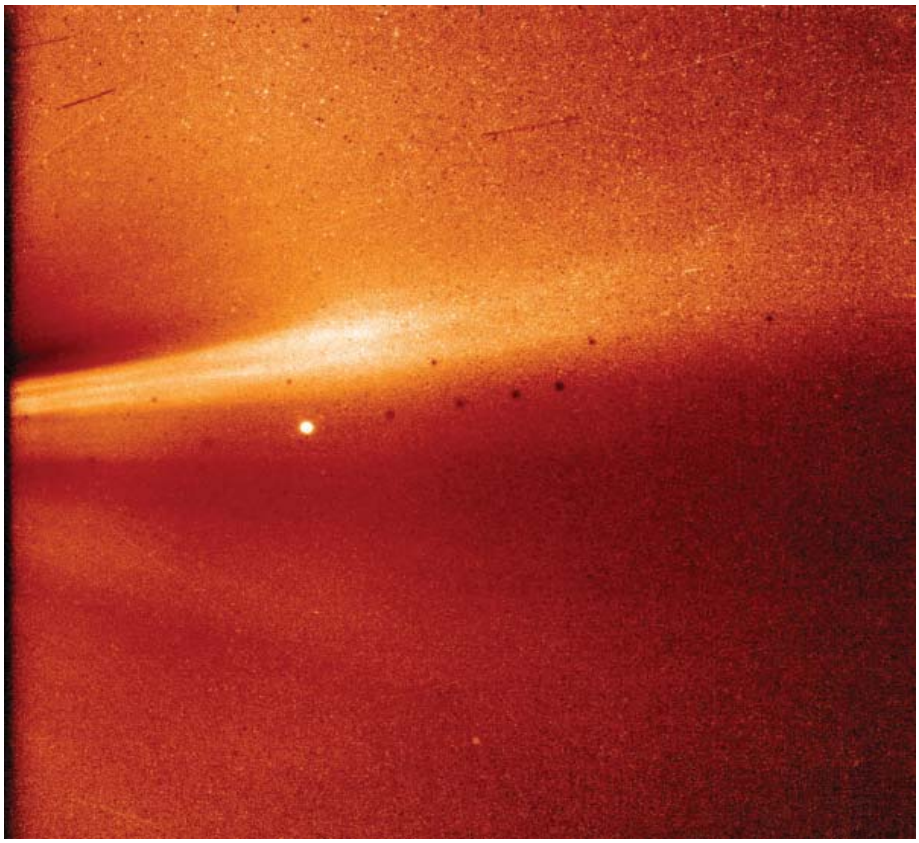
OSIRIS-REx will begin mapping the asteroid's surface in February for potential sampling locations. The rougher than expected surface may require a closer and more detailed characterization of the global boulder field. The current plan is for the spacecraft to come within three quarters of a mile (1.25 km) of the surface in its orbit. Sampling (at least two ounces or 60 grams and up to a maximum of 4.4 pounds or 2 kgs) is planned for mid-2020, with sample return to Earth in September 2023.

Report from First Encounter

The Parker Solar Probe completed its first solar encounter between October 31st and November 11th, but due to its proximity to the Sun (a strong emitter of radio waves) and the spacecraft's position with respect to the Earth, communications from the spacecraft were limited to an acknowledgement that its four suites of state-of-the-art instruments had survived the encounter and were fully functional.

Now with increased separation and a more favorable alignment, the spacecraft is beginning to transmit scientific data. As seen in the photo, Parker Solar Probe's WISPR (Wide-field Imager for Solar Probe) imaged a coronal streamer on the Sun's limb during the pass. The streamers are structures within the Sun's atmosphere usually associated with the Sun's active regions. The full download may not be available until after the second encounter in April.

The Parker Solar Probe spacecraft is designed to explore the Sun's outer atmosphere which can be heated to several million degrees (hundreds of times hotter than the photosphere on the next page). Its instruments will study the solar wind - charged particles which can be accelerated to velocities approaching the speed of light, in its multiple trips through the solar corona.



A coronal streamer captured by the Parker Solar Probe from about 16.9 million miles (27.2 million km) from the Sun's surface. The bright object is the planet Mercury-the dark spots artifacts from processing. Credits: NASA/Naval Research Laboratory/Parker Solar Probe

SpaceX Commercial Crew Update

SpaceX and NASA are targeting January 17th for the first demonstration flight of SpaceX's Crew Dragon spacecraft to the International Space Station. Launched from the Kennedy Space Center, Florida, the unmanned flight will be used to test ground support systems, autonomous docking, and landing procedures in anticipation of a manned flight later in 2019.

Crew Dragon at SpaceX's Kennedy Space Center facility in preparation for its first flight Image Credit: SpaceX

Journey to the Far Side

China launched its Chang'e 4 lunar probe (comprised of a lander and rover) from the Xichang Satellite Launch Center on December 7th. The spacecraft achieved lunar orbit five days later. On December 29th, Chang'e-4 entered a highly elliptical orbit, taking the space-craft within 9.3 miles (15 km) of the surface in preparation for landing on January 2nd (EST). It is the first soft landing on the far side of the Moon. The probe landed in the Von Karman crater which is located within the South Pole-Aitken impact basin, the largest and oldest impact basin on the Moon (with a diameter of 1,550 miles or 2,500 km). Its rover, Yutu 2, rolled onto the surface 12 hours later.

The launch of the Chang'e 4 lunar probe atop of a Long March 3B rocket on December 7th. Credit: Jiang Hongjing/ Xinhua/Zuma

Virgin Galactic Takes Flight

On December 13th, test pilots Mark Stucky and Frederick ("CJ") Sturckow flew Virgin Galactic's SpaceShipTwo "Unity" to an altitude of 51 miles (83 km). It was

Virgin Galactic's SpaceShipTwo under powered flight climbs toward the edge of space. Credit: MarsScientific.com & Trumbull Studios/Virgin Galactic

VSS Unity glides back to the Mojave Air and Space Port. Credit: Gene Blevins/LA Daily News/SCNG

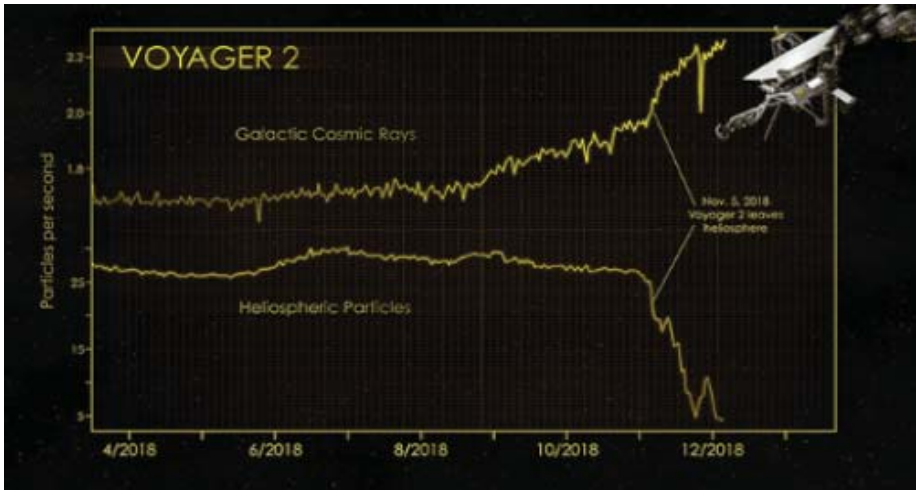
the first time that a private spacecraft flew high enough for its pilots to qualify for their "astronaut wings," as defined by the U.S. Air Force. The Federal Aviation Administration (FAA) will present Stucky and Sturckow with the FAA's Commercial Astronaut Wings at a ceremony in the New Year. Sturckow, a research pilot and former NASA astronaut (with four space shuttle missions), will become the only person recognized by both NASA and the FAA as an astronaut. [NASA and the Fédération Aéronautique Internationale currently consider the Kármán line at 62 miles (100 km) as the beginning of space but the Air Force recognizes a lower 50 mile boundary).

The test flight began with Virgin Galactic's WhiteKnight Two carrier aircraft taking off from the Mojave Air and Space Port in southern California with SpaceShipTwo mounted underneath. The mothership climbed to an altitude of 43,000 feet (13.1 km) where it released SpaceShipTwo. The piloted spacecraft then proceeded to fire its thermoset plastic-fueled rocket engine for approximately 60 seconds, accelerating to 2.9 times the speed of sound before coasting to the record making altitude.

The 60 foot (18.3 meters) long, carbon composite SpaceShipTwo has a wingspan of 27 feet (8.2 meters) and is designed to carry six passengers, in addition to the two crew members. December's flight is a major breakthrough in Virgin Galactic's commercial venture. The company suffered a significant setback in October 2014 when its first spaceship broke apart in flight, killing the co-pilot. While there's still more testing scheduled for the spacecraft, Richard Branson is looking forward to the day paying passengers will get to enjoy about four minutes of weightlessness from an altitude where the curvature of the Earth will be set against the blackness of space.

Voyager 2 Has Left the Solar System

In November, Voyager 2 joined its twin spacecraft Voyager 1 in interstellar space (Voyager 1 had crossed into this region of the solar system in 2012). Interstellar space is defined as the region beyond the Sun's heliosphere, a region dominated by the Sun's solar wind and magnetic field. The heliosphere provides refuge for the Earth and other worlds in the solar system from high energy galactic hazards such as cosmic rays.



Voyager 2 is now more than 11 billion miles (18 billion km) from Earth. At the speed of light, one-way communications with Voyager take about 16.5 hours. The spacecraft, launched in 1977, completed flybys of Jupiter, Saturn, Uranus and Neptune before heading out of the solar system. Its Plasma Science Experiment (PLS)

instrument had been reporting on the speed, density, temperature, pressure and flux of the solar wind - plasma flowing from the Sun. In early November, PLS recorded a sharp drop in the speed of the charged particles that comprise the solar wind. This was followed by large increase in cosmic ray detections.

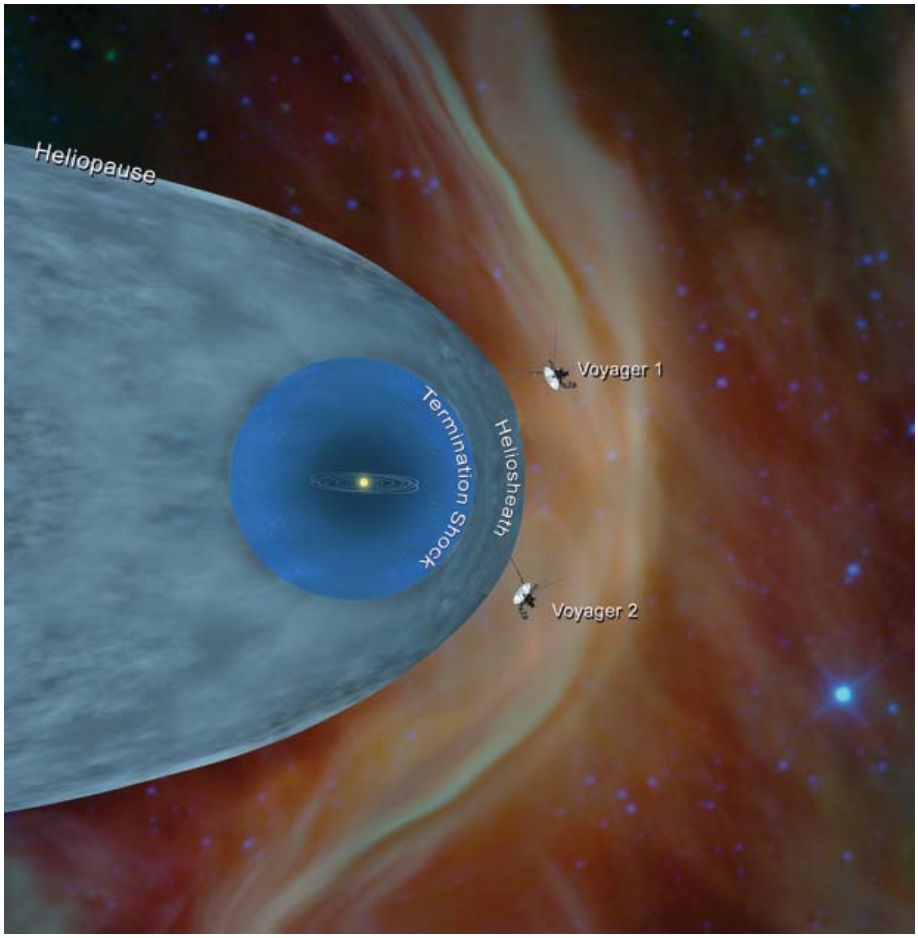
Lost Opportunity

The Mars Exploration Rover "Opportunity" landed on Mars' Meridiani Planum, on January 25, 2004. In over 14 years of exploration, the intrepid rover found conclusive evidence that billions of years ago Mars was wetter and warmer with conditions conducive to microbial life.

Opportunity trekked across the Martian plains, visiting several impact craters while escaping treacherous dunes and surviving cold, power-starving winters. The diminutive, six-wheeled, solar powered explorer covered a total of 28 miles (45 km) in its travels. It was exploring a cut-through in the wall of Endeavour Crater in May of 2018 when the skies began to darken. In early June, a regional dust storm blossomed into a global, sun-blocking tempest. The power output from Opportunity's solar panels plummeted with the skies as dark as night and dust coating its panels. On June 10th, Opportunity transmitted what was to be its last report. The rover has not been heard from since, despite clearing skies and routine monitoring by NASA's Deep Space Network.

Explorer 1

Fifty years ago, on January 31, 1958, the United States successfully launched its first satellite, Explorer 1. The launch occurred during the International Geophysical Year, a



NASA illustration showing the Voyager 1 and Voyager 2 spacecraft in interstellar space. Voyager 2 crossed the heliosheath, the outermost part of the heliosphere in November 2018. Voyager 1 had made the transition, in a different location, in 2012. Credit: NASA/JPL-Caltech

The image of Perseverance Valley (Endeavour Crater) shows the Opportunity rover as a tiny dot with the white square. The image was captured by NASA's Mars Reconnaissance Orbiter HiRISE a high-resolution camera once the skies had sufficiently cleared.

Credits: NASA/JPL-Caltech/Univ. of Arizona

global initiative which actually ran from July 1957 to December 1958 and coincided with the peak in the 11-year solar cycle. Unlike Sputnik 1, which had been launched by the Soviet Union in October of 1957 and designed to only broadcast radio pulses (or Sputnik 2 which carried a dog into space as a crude biological demonstration), Explorer 1 carried a suite of instruments to study cosmic rays, micrometeoroids, and the satellite's temperature. It was the first artificial satellite designed to return scientific data.

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

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

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

In August 2012, NASA launched the Van Allen Probes to study this dynamic region of space (*http://vanallenprobes.jhuapl.edu/*). With two identical spacecraft, traveling in tandem, scientists are able to measure changes in the belts over time and space. The probes have provided researchers a new understanding of how the belts respond to fluctuations in the Sun's output. With a number of unexpected scientific discoveries the original two year mission was extended. However, the probes are running low on fuel and the mission will likely end in 2020.

January History

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

Sergei Korolyov, the "Chief Designer" of the Soviet space program, died on January 14, 1966 from a botched medical procedure. Korolyov co-founded the Moscow rocketry organization in the 1930s

before being thrown into prison during the peak of Stalin's purges. He spent a year in the Kolyma gold mine, the most dreaded part of the Gulag in Siberia before he was recalled to Moscow to aid the Red Army in developing new weapons. Korolyov went on to lead the Soviet space effort. Unfortunately, the Soviet Moon program died with Korolyov in 1966. While the race continued for some time after his death, his N-1 moon rocket never made a successful flight.

Space Mirror Memorial on the grounds of the Kennedy Space Center Visitor Complex

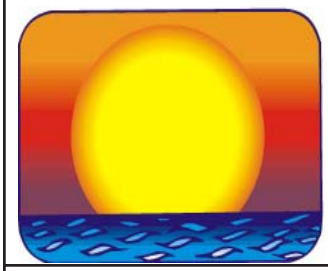
The crew of Apollo 1 crosses the gantry to the spacecraft on the day of the fire, Jan. 27, 1967.

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

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

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

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



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
January 1st (EDT)	07:20	16:34
January 15th (EST)	07:18	16:48
January 31st (EST)	07:06	17:08

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

If you are out observing the open star clusters Pleiades or Hyades in the constellation Taurus, don't overlook the red giant Aldebaran. This star is receding from us more rapidly than any other 1st magnitude star in the sky. It was the brightest star in the sky some 320,000 years ago when it was 21½ light years from Earth. Moving away, Aldebaran is currently 65 light years in distance and the thirteenth brightest star in the sky.

Astronomical and Historical Events

1st Flyby of the Kuiper Belt Object 2014 MU69 (Ultima Thule) by the New Horizons spacecraft
1st Apollo Asteroid 2007 YQ56 near-Earth flyby (0.076 AU)
1st Apollo Asteroid 2009 BD closest approach to Earth (1.762 AU)
1st History: GRAIL-B spacecraft enters lunar orbit (2012)
1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, Ceres (1801)
2nd History: flyby of comet Wild 2 by the Stardust spacecraft (2004)
2nd History: launch of the Soviet spacecraft Luna 1; first probe to fly by the Moon (1959)
3rd Kuiper Belt Object 2014 WP509 at Opposition (41.639 AU)
3rd Earth at Perihelion - closest distance from Sun (0.983 AU)
3rd Quadrantids meteor shower peaks; radiates from the constellation Boötes (name from an obsolete constellation called Quadrans Muralis)
3rd History: exploration rover Spirit lands on Mars in Gusev Crater; operational for six years before getting bogged down in loose soil at a winter haven called Troy (2004)
3rd History: Stephen Synnott discovers Uranus' moons Juliet and Portia (1986)
4th Apollo Asteroid 2014 AD16 near-Earth flyby (0.033 AU)
4th Apollo Asteroid 2004 XP14 near-Earth flyby (0.073 AU)
4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
5th New Moon
5th History: launch of the Soviet atmospheric probe, Venera 5, to Venus (1969)
5th History: discovery of dwarf planet Eris (the Pluto killer) by Mike Brown, et al. (2005)
5th History: discovery of Jupiter's moon Elara by Charles Perrine (1905)
6th Venus at its greatest western elongation (apparent separation from the Sun) in the morning sky (47°)
6th History: launch of the Lunar Prospector spacecraft; detected signs of water ice in permanently shadowed craters, mapped surface composition and Moon's gravity field and detected outgassing events in the vicinity of craters Aristarchus and Kepler (1998)
6th History: La Criolla (Argentina) meteorite fall (1985)

Astronomical and Historical Events (continued)

6th History: launch of Surveyor 7, the last of the unmanned Surveyor spacecrafts; soft-landed near Tycho crater (1968)
7th Apollo Asteroid 2016 AZ8 near-Earth flyby (0.030 AU)
7th Apollo Asteroid 2017 MZ near-Earth flyby (0.096 AU)
7th History: discovery and first recorded observations of Jupiter's four largest moons Io, Europa, Ganymede and Callisto by Galileo Galilei (1610)
8th Moon at apogee (furthest distance from Earth)
8th History: launch of Japanese spacecraft Sakigake with mission to rendezvous with Comet Halley; measured the solar wind and magnetic field (1985)
8th History: launch of Luna 21 and the Lunokhod 2 moon rover (1973)
8th History: Stephen Hawking born (exactly 300 years after the death of Galileo); discovered that black holes could emit radiation - subsequently known as Hawking radiation (1942)
9th Apollo Asteroid 2013 YM2 near-Earth flyby (0.019 AU)
9th Kuiper Belt Object 230965 (2004 XA192) at Opposition (34.594 AU)
9th History: Voyager 2/Stephen Synnott discovers Uranus' moon Cressida (1986)
10th Aten Asteroid 2008 CH70 near-Earth flyby (0.067 AU)
10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)
10th History: U.S. Army first bounces radio waves off the Moon (1946)
11th Amor Asteroid 2018 VW6 near-Earth flyby (0.077 AU)
11th History: the Lunar Prospector spacecraft enters lunar orbit for a nineteen month chemical map ping mission (1998)
11th History: William Herschell discovers Uranus' moons Titania and Oberon (1787)
12th Second Saturday Stars - Open House at the McCarthy Observatory
12th History: launch of the Deep Impact spacecraft for a flyby of comet Tempel 1; a small "impactor" was later released from the main spacecraft for a July 4th collision with the comet's nucleus (2005)
12th History: Sergei Pavlovich Korolyov born, Chief Designer of the Soviet space program (1907)
13th Apollo Asteroid 2018 AN2 near-Earth flyby (0.065 AU)
13th History: Stephen Synnott discovers Uranus' moons Desdemona, Rosalind and Belinda (1986)
13th History: discovery of the Martian meteorite EETA 79001 in Antarctica; second largest Martian meteorite recovered after Zagami (1980)
14th First Quarter Moon
14th Aten Asteroid 2340 Hathor closest approach to Earth (0.144 AU)
14th History: first of three flybys of the planet Mercury by the Messenger spacecraft (2008)
14th History: landing of the Huygens probe on Saturn's largest moon Titan (2005)
15th Aten Asteroid 2016 DL near-Earth flyby (0.053 AU)
15th Amor Asteroid 433 Eros closest approach to Earth (0.209 AU)
15th History: Stardust spacecraft returns samples of Comet P/Wild 2 (2006)
15th History: launch of the spacecraft Helios 2, solar orbiter (1976)
15th History: Lunokhod 2, the second of two Soviet unmanned lunar rovers, lands in Le Monnier crater; covered a total distance of 23 miles (37 km) in almost five months of exploring the floor of the crater and its southern rim (1973)
16th Apollo Asteroid 2013 EC20 closest approach to Earth (0.883 AU)
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th Scheduled launch of SpaceX's Crew Dragon Demo 1 from the Kennedy Space Center, Florida. The unmanned spacecraft will fly to the International Space Station on a test flight under the auspices of NASA's commercial crew program
17th Atira Asteroid 2012 VE46 closest approach to Earth (0.399 AU)
17th History: Astronomer Edwin Hubble publishes paper that the Universe is expanding -"A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae" (1929)
17th History: launch of Jason 3, an ocean altimetry satellite from the Vandenberg Air Force Base, California (2016)

Astronomical and Historical Events (continued)

17th History: Pierre Mechain's discovery of Comet 2P/Encke (1786); short period comet that com pletes a circuit around the Sun every 3.3 years, named after Johann Encke who computed the comet's orbit, recognizing it as a periodic comet
18th Apollo Asteroid 1620 Geographos closest approach to Earth (0.611 AU)
19th Apollo Asteroid 515767 (2015 JA2) near-Earth flyby (0.063 AU)
19th Atira Asteroid 2017 YH closest approach to Earth (0.185 AU)
19th History: launch of the New Horizons spacecraft to Pluto; executed a close encounter with the dwarf planet in July 2015 (2006)
19th History: discovery of the Martian meteorite SAU 090, a basaltic shergottite, in Oman (2002)
19th History: discovery of Saturn's moon Janus by the Voyager 1 spacecraft (1980)
19th History: launch of Gemini 2, an unmanned suborbital flight designed to test the spacecraft's heat shield (1965)
19th History: Johann Bode born, popularized an empirical law on planetary distances originally de veloped by J.D. Titius, known as "Bode's Law" or "Titius-Bode Law" (1747)
20th Apollo Asteroid 2329 Orthos closest approach to Earth (2.876 AU)
20th History: Rich Terrile discovers Uranus' moons Cordelia and Ophelia (1986)
21st Full Moon
21st Total Lunar Eclipse and Super Moon
21st Moon at perigee (closest distance from Earth)
21st History: launch of the rocket Little Joe-1B and a rhesus monkey named "Miss Sam" in a successful test of the Mercury capsule's escape system (1960)
21st History: John Couch Adams born, astronomer and mathematician who was the first person to predict the position of a planet beyond Uranus (1792)
22nd Amor Asteroid 4055 Magellan closest approach to Earth (1.436 AU)
22nd Kuiper Belt Object 20000 Varuna at Opposition (42.948 AU)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd Atira Asteroid 1998 DK36 closest approach to Earth (1.249 AU)
23rd History: Brad Smith discovers Uranus' moon Bianca (1986)
24th Amor Asteroid 2015 BG4 near-Earth flyby (0.075 AU)
24th History: launch of space shuttle Discovery (STS-51-C); 100th human spaceflight to achieve orbit (1985)
24th History: discovery of the Martian meteorite Dhofar 019 in Oman (2000)
24th History: launch of Japan's Hiten spacecraft; first use of a low-energy transfer to modify an orbit and the first demonstration of a transfer to the Moon requiring no change in velocity for capture (1990)
24th History: flyby of Uranus by the Voyager 2 spacecraft (1986)
25th Apollo Asteroid 3671 Dionysus closest approach to Earth (2.306 AU)
25th Plutino 208996 (2003 AZ84) at Opposition (43.494 AU)
25th History: exploration rover Opportunity lands on Mars at Meridiani Planum; operated for over 14 years before being crippled by a global dust storm in 2018 (2004)
25th History: launch of the Infrared Astronomical Satellite (IRAS); first space telescope to survey of the entire sky at infrared wavelengths (1983)25th History: launch of the U.S. Moon orbiter Clementine (1994
25th History: Joseph Lagrange born (1736); mathematician who discovered five special points in the vi cinity of two orbiting masses where a third, smaller mass can orbit at a fixed distance from the larger masses. The L1 Lagrange Point of the Earth-Sun system is the current home of the Solar and Heliospheric Observatory Satellite (SOHO)
26th Apollo Asteroid 136617 (1994 CC) (2 Moons) closest approach to Earth (1.319 AU)
26th History: discovery of dwarf planet Haumea's moon Hi'laka by Mike Brown, et al. (2005)
26th History: discovery of Saturn's moon Epimetheus by the Voyager 1 spacecraft (1980)6th His tory launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27th Last Quarter Moon

Astronomical and Historical Events (continued)

27th History: fire in the Apollo 1 spacecraft kills astronauts Gus Grissom, Edward White and Roger Chaffee (1967)
27th History: Philibert Melotte discovers Jupiter's moon Pasiphae (1908)
28th Comet 1P/Halley at Opposition (33.845 AU)
28th History: final launch of the space shuttle Challenger (STS-51L); lost on lift-off (1986)
28th History: Johannes Hevelius born; leading observational astronomer of the 17th century, published detailed maps of the Moon and determined the rotational period of the Sun (1611)
29th Aten Asteroid 2013 CW32 near-Earth flyby (0.036 AU)
29th History: Soviet spacecraft Phobos 2 enter orbit around Mars; successfully returned 38 images be fore contact was lost; its lander was not deployed (1989)
30th Scheduled launch of India's Chandrayaan 2 lunar mission from the Satish Dhawan Space Center, Sriharikota, India's second lunar mission, Chandrayaan 2 will consist of an orbiter, a lander and a rover.
30th History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st History: launch of Apollo 14; third manned moon landing with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell (1971)
31st History: launch of Soviet Moon lander Luna 9; first spacecraft to land and to transmit photographs from the Moon's surface (1966)
31st History: launch of Mercury-Redstone 2 rocket with Ham the chimpanzee (1961)
31st History: launch of the first U.S. satellite, Explorer 1; detected inner radiation belt encircling the Earth (1958)

Commonly Used Terms

- **Apollo**: A group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- **Aten**: A group of near-Earth asteroids whose orbits also cross Earth's orbit, but un like 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°)
• One astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

Solar Activity

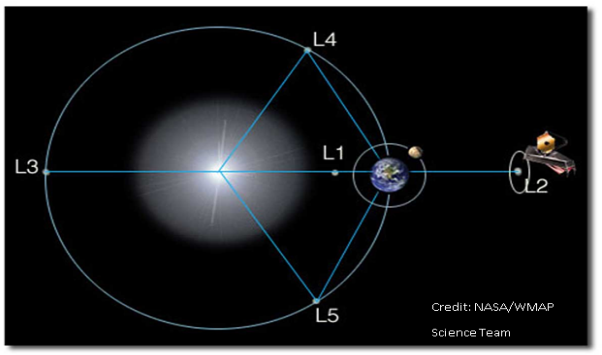
For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out *www.spaceweather.com.*

International Space Station and Iridium Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

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 1.5 million kilometers beyond the Earth (as viewed from the Sun).



NASA's Global Climate Change Resource

Vital Signs of the Planet: https://climate.nasa.go

Image Credits

Front page design and graphic calendar: Allan Ostergren

Second Saturday Stars poster: Marc Polansky

All other non-credited photos were taken by the author: Bill Cloutier

Front Page Image

NGC 1015 is a barred spiral galaxy, at a distance of 118 million light years from Earth in the constellation Cetus (*The Whale*). Its broad swirling tentacles and bright glow - generated by intensive star formation in the center of the galaxy - are possibly enhanced by the gravitational attraction of massive black holes.

The intense glow and pyrotechnics exhibited by NGC 1015 have been likened to a giant fire-spitting pinwheel, or *Catherine wheel*, after Saint Catherine of Alexandria, a 4th century Christian martyr who was condemned to *breaking on the wheel*. Legend says that Catherine was ultimately beheaded after the wheel mysteriously shattered into pieces whenever she touched it—a tragic, but fitting metaphor for the life, death and rebirth of stars.

Credit: ESA/Hubble & NASA, A. Riess (STScI/JHU)

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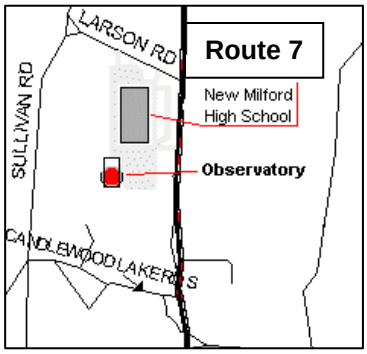

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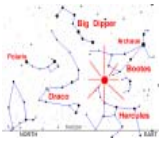
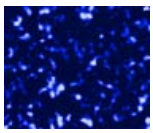
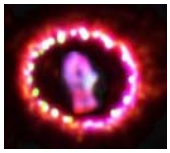
January 2019

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		1 Moon at apogee (furthest from the Earth)   Giuseppe Piazzi discovers Ceres, 1st asteroid, now dwarf planet (1801)  GRAIL-B spacecraft enters lunar orbit (2012)	2  Soviet spacecraft Luna 1 circles Moon (1959)  Flyby of comet Wild 2 by Stardust spacecraft (2004)	3  Rover Spirit on Mars (2004)  Quadrantids meteor shower peak	4  Isaac Newton born (1643)	5  Discovery of Jupiter's moon Elara by Charles Dillon Perrine (1905)
6  La Criolla (Argentina) meteorite fall (1985)  Launch of Lunar Prospector: detected signs of water ice in shadowed craters, mapped surface composition and Moon's gravity field (1998)	7  Launch of Surveyor 7, the last of the Surveyor Lunar landers; soft-landed near Tycho crater (1968)  Discovery and first recorded observations of Jupiter's four largest moons by Galileo Galilei (1610)	8 Moon at apogee (furthest from the Earth)  launch of Luna 21 and the Lunokhod 2 moon rover (1973)   Launch of Japanese spacecraft Sakigake to Comet Halley (1985)  Stephen Hawking born (1942)	9  Physicists at Fermilab and Berkeley unveil maps of the invisible scaffolding of the universe - dark matter (2012)	10  U.S. Army bounces radio waves off the Moon (1946)  Surveyor 7 lands on Moon (1968)	11  William Herschell discovers Uranus moons Titania and Oberon (1787)	12 Launch of Deep Impact spacecraft for flyby of comet Tempel 1 (2005)   Sergei Pavlovich Korolyov born, designer of Soviet space program (1907) 2nd Saturday Stars Open House McCarthy Observatory 
13 Moon at apogee (furthest from the Earth) Discovery of Uranus moons Desdemona, Rosalind and Belinda by Stephen Synnott (1986)   Discovery of Martian meteorite EETA 79001 in Antarctica (1980)	14  Landing of the Huygens probe on Saturn's largest moon Titan (2005) Messenger spacecraft flyby of Mercury (2008) 	15  Stardust spacecraft returns with samples of comet P Wild 2 (2006) Launch of Helios 2, solar orbiter (1976) 	16  Final launch of space shuttle Columbia (2003)	17  Harvey H.Nininger born, American meteoriticist and founder of the American Meteorite Museum near Meteor Crater, Arizona (1887)	18  Astronomers discover a pulsar in remnants of Supernova 1987A, but observation not later confirmed (1989)	19 discovery of the Martian meteorite SAU 090 in Oman (2002)   of ... Horizons spacecraft to Pluto (2006) Johann Bode born, developed law on planetary distances (1747) 
20  Rich Terrile discovers Uranus' moons Cordelia and Ophelia (1986)	21 Moon at perigee (closest distance to Earth)  Launch of the rocket Little Joe-1B and a rhesus monkey "Miss Sam" (1960)   John Couch Adams born, predicted planet beyond Uranus (1792)	22 Apollo 5 launch to Moon (1968)	23 Discovery of Uranus' moon Bianca by Brad Smith (1986)	24 Discovery of the Martian meteorite Dhofar 019 in Oman (2000) Rover Opportunity arrives on Mars (2004) Flyby of Uranus by Voyager 2 (1986)	25 Launch of the Infrared Astronomical Satellite (IRAS): first space telescope to survey of the entire sky at infrared wavelengths (1983) Joseph Louis Lagrange born (1736) Launch of U.S. Moon orbiter Clementine (1994) 	26 Discovery of Saturn's moon Epimetheus by the Voyager I spacecraft (1980) Launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27 Philibert Melotte discovers Jupiter's moon Pasiphae (1908) Fire in Apollo 1 spacecraft (1967)	28 Johannes Hevelius born (1611) Space shuttle Challenger lost on lift-off (1986)	29 Phobos 2, Soviet spaecraft enters Mars orbit in study of solar environment. Mission, with cooperation of U.S and 3 others (1989)	30 John Herschel uses camera obscura and hyposulphite to fix "snapshot" images from 48" (120cm) telescope (1839)	31 Apollo 14, 3rd Moon mission (1971) Explorer 1, first U.S. satellite (1958) *Ham* Launch of Mercury-Redstone 2 rocket with Ham, the astrochimp (1961)	Phases of the Moon Jan 5 Jan 14 Jan 21 Jan 27