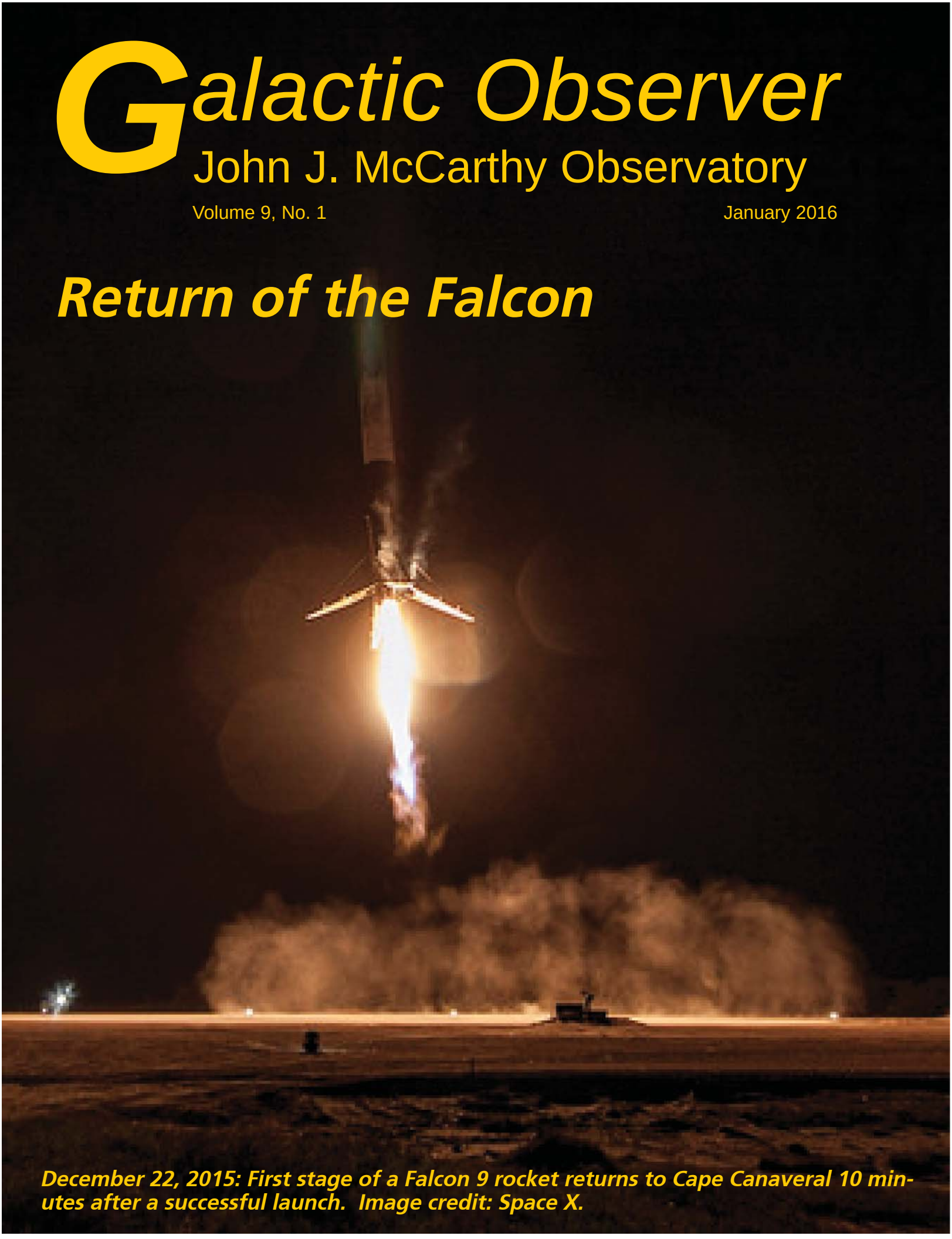
Galactic Observer

John J. McCarthy Observatory

Volume 9, No. 1 January 2016

Return of the Falcon



December 22, 2015: First stage of a Falcon 9 rocket returns to Cape Canaveral 10 minutes after a successful launch. Image credit: Space X.

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It is through their efforts that the McCarthy Observatory has established itself as a significant educational and recreational resource within the western Connecticut community.

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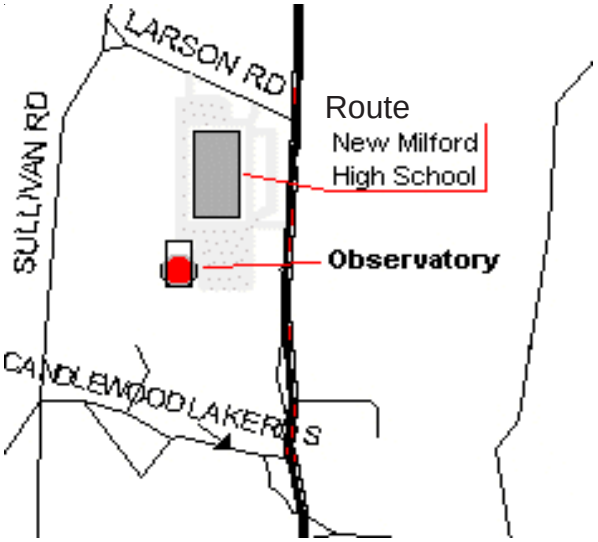

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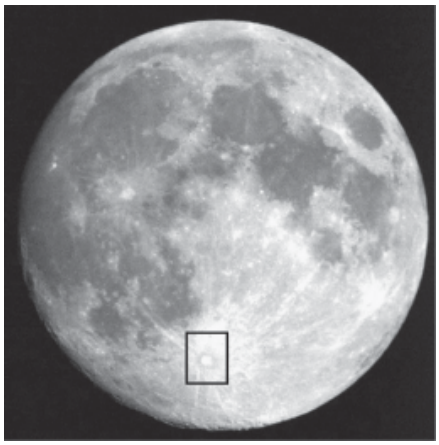
IT'S BEEN OVER 40 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural 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).

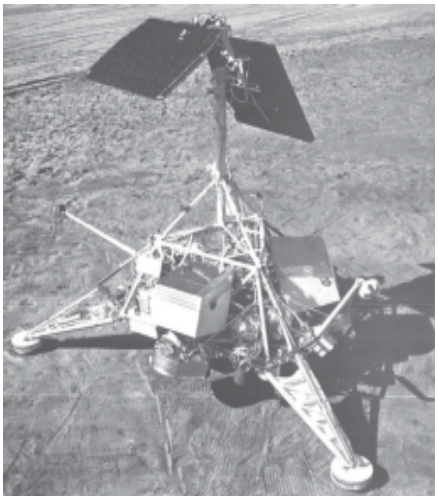


Tycho crater and landing site of Surveyor 7

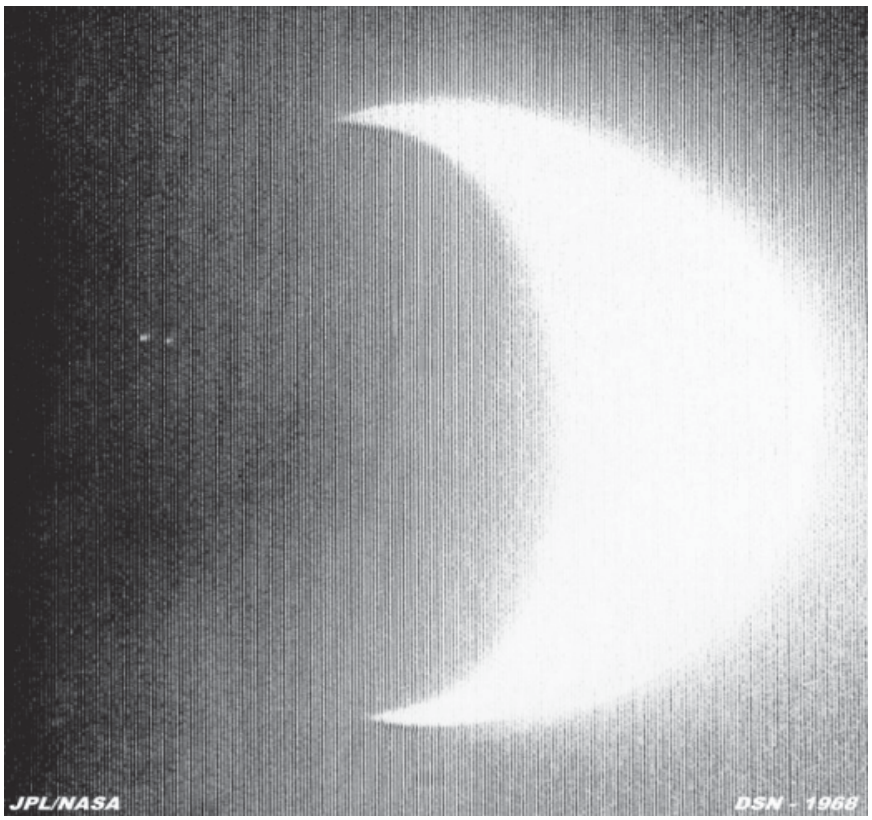
The view this month is the region around Tycho crater, one of the youngest, large impact craters on the Moon (53 miles or 85 km in diameter and estimated to be 108 million years old). The crater was targeted for a visit by Apollo 20 (circa 1972) before the mission was canceled due to budget cuts.

In January 1968, an unmanned spacecraft landed approximately 18 miles north of the rim of Tycho crater. Surveyor 7 was the last of the U.S. robotic probes to explore the Moon in advance of the Apollo missions and the fifth to achieve a soft landing. The Surveyor missions were used to validate landing technology and confirm surface conditions for future landings. Details of the program and a compilation of its results can be found in NASA publication SP-184 issued in 1969 and available on the internet.

Surveyor 7 returned 20,993 pictures in its first lunar day (lunar days are approximately 14 Earth days long). Despite battery damage from the cold lunar night, 45 additional pictures were returned on the second lunar day. On January 20th, the spacecraft took part in a laser pointing demonstration (in advance of the Apollo astronauts placing reflector arrays on the Moon). Six transmission sites were established on Earth, each using a telescope (backwards) to direct an argon laser beam towards the landing site. Perkin-Elmer in Norwalk participated, attaching a 2-watt laser to the Cassegrain focus of a 24-inch telescope. Surveyor 7's camera was able to record the lasers from both the Kitt Peak and Table Mountain observatories.

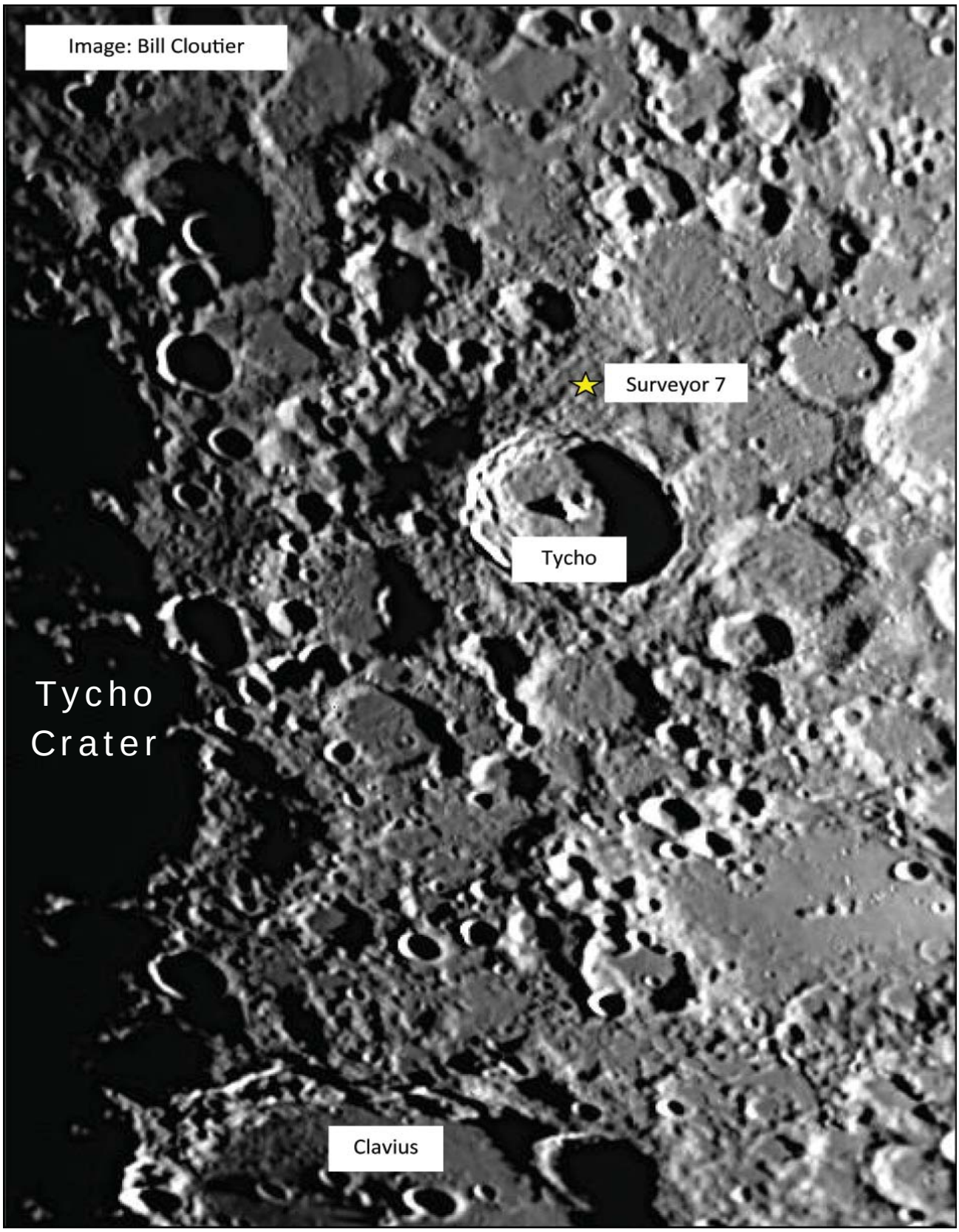


Surveyor Lunar Lander model (on Earth). Credit: NASA



The Surveyor 7 television camera recorded two laser beams in this image taken on January 20th. The overexposed crescent is the Earth and the two bright dots to its left are the laser beams. The beam spot on the far left is from JPL's 24-inch telescope at the Table Mountain Observatory near Wrightwood, California. The adjacent beam spot is from the Kitt Peak National Observatory's McMath solar telescope.

Five retroflector arrays would be left on the Moon by the U.S. (3) and Soviet Union (2). The prisms for the U.S. arrays carried to the Moon by the crews of Apollo 11, 14 and 15 were manufactured by the Perkin-Elmer Corporation. Laser ranging from observatories on Earth have provided precision measures of the Earth-Moon distance (averaging 239,000 miles or 385,000 km), the rate at which the Moon is moving away from the Earth (approximately 1.5 inches or 3.8 cm per year) and variations in the rotation of the Moon.



Planets in 2016

The outer planets return to the evening sky in the first half of 2016. Jupiter is closest to Earth on March 8th when it reaches Opposition (opposite the Sun in the sky, rising with the setting Sun and visible all night). The gas giant can be found in the constellation Leo. Mars reaches Opposition on May 22nd, appearing in the constellation Scorpius. Saturn joins Mars less than two weeks later, reaching Opposition on June 3rd and appearing in the constellation Ophiuchus.

The year starts off with a morning pairing of Saturn and Venus. The gap between the planets shrinks to less than 0.5 degrees (or the apparent width of a full Moon) on January 9th. Saturn and Venus will be visible just before sunrise in the southeast with Venus being noticeably brighter.

On May 9th, the planet Mercury crosses in front of or transits the Sun (as viewed from Earth). Transits occur infrequently (the next transit will be in 2019 and then not again until 2039). The transit should only be viewed with the appropriate protective eyewear or through a solar filter.

On August 27th, the planets Venus and Jupiter will approach within 0.06 degrees in the evening sky for a spectacular conjunction of two of the brightest planets.

Deep Space Mission Milestones

After almost five years of deep space travel, the Juno spacecraft will reach Jupiter on July 4th. The solar powered spacecraft will spend 20 months orbiting Jupiter (37 orbits), studying the planet's gravitational and magnetic fields as well as the gas giant's dynamic atmosphere.

New Missions

In January, a SpaceX rocket is scheduled to carry Jason 3 into Earth orbit. The spacecraft is the fourth in a series of ocean monitoring (surface height) satellites. Jason 3's altimeter is designed to measure variations in global ocean to an accuracy of 1.3 inches or 3.3 centimeters, or better.

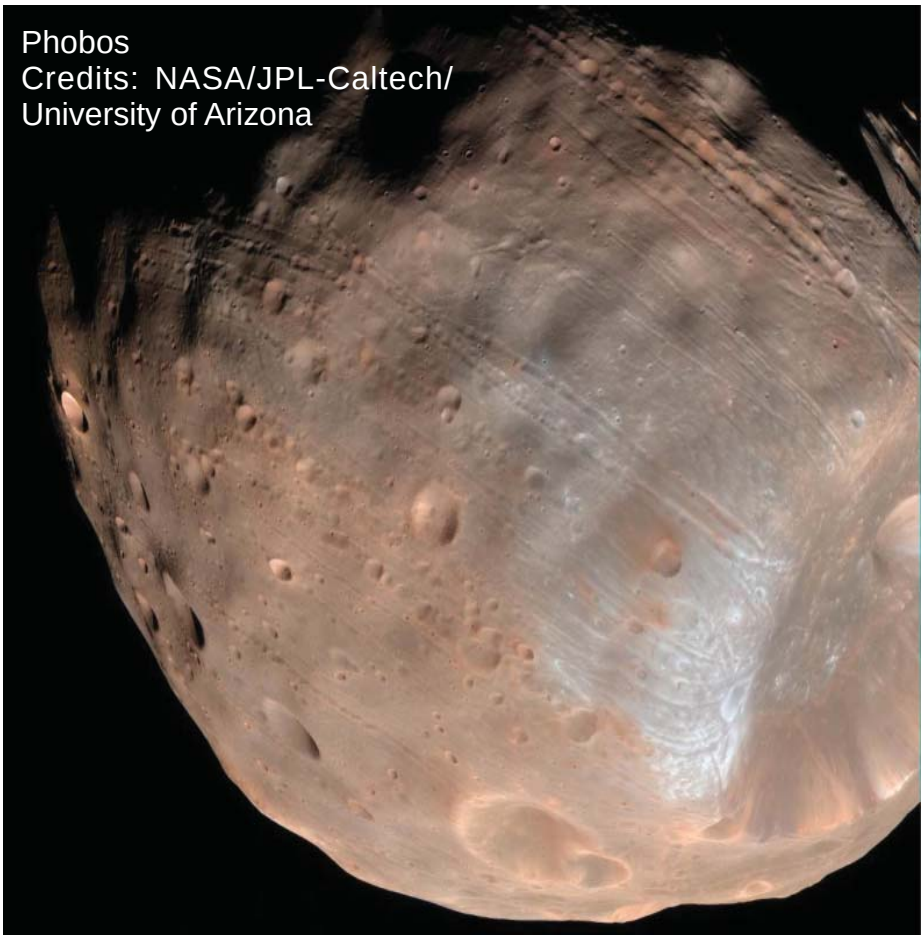
In February, a Japanese H-2A rocket is scheduled to carry the Astro-H X-ray observatory into low-Earth orbit (deployed at an altitude of 340 miles or 550 km). The telescope, 46 feet or 14 meters when fully extended, will observe X-ray emitting objects such as black holes, supernova remnants and galaxy clusters.

In March, a Russian Proton rocket is scheduled to launch the European Space Agency's ExoMars Trace Gas Orbiter and Schiaparelli demonstration lander to Mars. The orbiter will measure trace gas concentrations in the Martian atmosphere such as methane. Data collected by the orbiter will be used to select a landing site for a rover to be launched in 2018.

In September, an Atlas 5 rocket will launch the OSIRIS-Rex spacecraft towards the asteroid 101955 Bennu on a sample return mission. The spacecraft is scheduled to reach Bennu in 2018 and return samples (about 2 ounces or 60 grams) to Earth in 2023. The carbonaceous and potentially hazardous Apollo asteroid has a diameter of approximately 538 yards (492 meters). Discovered in 1999, Bennu completes an orbit around the Sun every 1.2 years with a close encounter with Earth every six years.

The Demise of Phobos

Phobos, the larger of the two moons of Mars, orbits at a dis-



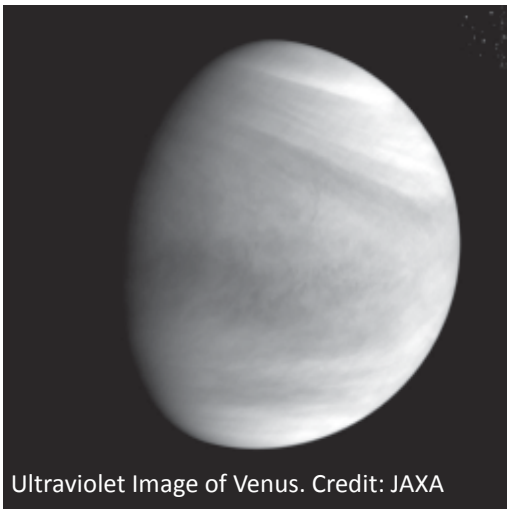
Phobos
Credits: NASA/JPL-Caltech/ University of Arizona

tances of only 3,700 miles (6,000 km). At this distance, gravity is slowly drawing Phobos closer to the Red Planet (approximately 7 feet or 2 meter every hundred years). Expectations are that, within 30 to 50 million years, the moon will be torn apart by Mars' gravitation forces. The grooves seen on Phobos may be indicative of tidal stresses that will eventually destroy the moon and create a ring of debris around Mars.

Named after one of the offspring of the Greek war god Ares and Aphrodite, Phobos (fear) was discovered in 1877 by Asaph Hall from the U.S. Naval Observatory. The moon is 10 by 14 by 11 miles (17 by 22 by 18 km) and orbits Mars three times a day.

Venus or Bust

Japan's space agency (JAXA) Akatsuki spacecraft finally achieved orbit around Venus, five years later than originally planned. The spacecraft had failed to enter orbit in December 2010 when its main engine was damaged during a burn. This time around, without the use of the main engine, JAXA engineers used Akatsuki's smaller maneuvering thrusters to slow the spacecraft for capture by Venus' gravity. The successful tactic placed the spacecraft in a highly elliptical orbit that brings Akatsuki as close as 248 miles (400 km) to the planet and as far as 273,000 miles (440,000 km). The spacecraft will orbit Venus every 13 to 14 days.



Ultraviolet Image of Venus. Credit: JAXA

Akatsuki's five cameras are designed to explore different levels of the thick atmosphere and to look for signs of active volcanoes and lightning. Engineers estimate that the spacecraft has enough fuel reserves for at least two years of operation.

New Horizons Update

Six months after a close encounter with Pluto, the New Horizons spacecraft is heading out into the Kuiper Belt at approximately 32,000 miles per hour (51,500 km/hr). It will be another three years before the spacecraft reaches its next target on January 1, 2019, a small object called 2014 MU69. Located nearly a billion miles (1.6 billion km) beyond the orbit of Pluto and taking almost 300 years to complete an orbit around the Sun, 2014 MU69 is only 30 miles (48 km) across. Scientists expect that the object may be a relic from the formation of the early solar system and relatively unchanged over the past 4.5 billion years.

The image (below) is of the al-Idrisi Mountains, likely comprised of water ice. The mountains, with peaks reaching a height of 1.5 miles (2.4 km), ends at the shore of Sputnik Planum, a nitrogen-rich icy plain. The image covers an area approximately 50 miles (80 km) wide.

Credit: NASA/JHUAPL/SWRI

12 Earth-Years on Mars

On January 25, 2004, the Mars Exploration Rover Opportunity entered the Martian atmosphere after a six month journey and bounced along the Martian surface in an inflatable cocoon before coming to rest in Eagle crater. While only 72 feet (22 meters) in diameter, small nodules of hematite (dubbed blueberries) in the rock layers that formed the crater wall provided the first clear evidence that liquid water played a role in geologic processes that transformed the Red Planet over the past 4 billion years. Eagle would be the first of several impact craters that Opportunity would explore as it traveled across the plains of Meridiani Planum.

Opportunity would spend the second half of 2004 traveling to and exploring nearby Endurance crater. In April 2005, the mission would be threatened when the rover became stuck in a sand dune. It would take six weeks of planning and many, centimeter-sized maneuvers to extract the rover. After escaping "Purgatory Dune," Opportunity narrowly avoided another dune when newly installed software stopped the rover before it lost traction. Circumventing the dune, Opportunity continued on its trek to Victoria crater, stopping by the smaller Erebus crater along the way. On its way, it would pass by its own discarded heat shield and the first of several meteorites.

The rover reached Victoria crater in September of 2006, after traveling 4.3 miles (7 km) from its landing site. It would spend the first nine months circumnavigating the crater's rim, during which it was photographed by the Mars Reconnaissance Orbiter. In mid-2007, a series of dust storms blotted out the Sun. The loss of power threatened to discharge the rover's battery and permanently disable the rover. By late August, however, the storms began to subside and Opportunity was receiving enough sunlight to recharge its battery and return to normal operation. The rover would spend another year exploring rock outcroppings within the crater.

Leaving Victoria, Opportunity would begin a three year journey to Endeavour crater, reaching the rim of the 14 mile (22km) diameter impact crater in August 2011. Shortly after arriving, the rover would discover gypsum deposits on the surface, a clear indication that water once flowed through the surrounding rock. In May 2013, the rover was directed to drive to a high ridge on the rim, designated Solander Point. The sun-facing slope of the ridge allowed Opportunity to continue to work through the Martian winter. On its trek, the rover discovered rocks dating back to the earliest geologic (Noachian) period, approximately 4 billion years ago.

During Opportunity's twelve Earth-years on Mars, the rover has found water-borne materials and minerals deposited by water (including hematite, clay and gypsum) conclusive signs that liquid water once flowed across or percolated through the Martian surface.

The 4.9 foot (1.5 m) high rover has survived dust storms, sand traps and equipment breakdowns. A malfunctioning heater switch has increased the electrical load. An inoperative shoulder azimuth joint limits the robotic arm movement. Non-functioning science instruments, sporadic issues with flash memory, and other glitches with software have affected Opportunity's operations as well. The rover drives backwards in an effort to prolong the life of a failing front wheel. Opportunity's ailments include a failed potentiometer in the arm, causing the rover to believe the arm has come unstowed (an event that would preclude driving). Despite the many challenges, Opportunity is still capable of executing its mission.

Opportunity is currently exploring Marathon Valley, an east-west cut through the western rim of the 14 mile (22 km) diameter Endeavour crater. The valley is of interest to mission scientists, due to the detection of clay minerals by orbiting spacecraft. With the Martian winter underway, Opportunity is working on a steep slope along the valley's southern wall. This is keeping the rover solar panels tilted toward the winter Sun, maximizing the available power.

To date, the cold winter skies have been relatively clear with a tau (measure of optimal depth where 0 represents perfectly clear skies) of 0.438 (tau levels reached a high of 5 during a power-crippling dust storm in 2007 when less than 1% of the direct sunlight reached the surface). Power levels are also good with 66% of the sunlight hitting the solar arrays penetrating the accumulated dust layer. The rover has been operating on Mars for almost 4,300 Martian Sols while driving over 26.5 miles since its landing on the Red Planet.

The rover's trek to Marathon Valley has already paid dividends. Scientists are intrigued with the red rock banding found in its walls and its correlation, if any, with the clay mineral signature.

Marathon Valley (looking down into Endeavor Crater). Image Credit: NASA/JPL-Caltech/Cornell Univ./Arizona State University.

Hinners Point looking up from the floor of Marathon Valley. Image Credit: NASA/JPL-Caltech/Cornell Univ./Arizona State University.

The image of Marathon Valley shows the steep slope leading down to the floor of Endeavour crater and the crater's far wall in the distance. Hinners Point is a ridge at the northern edge of the valley.

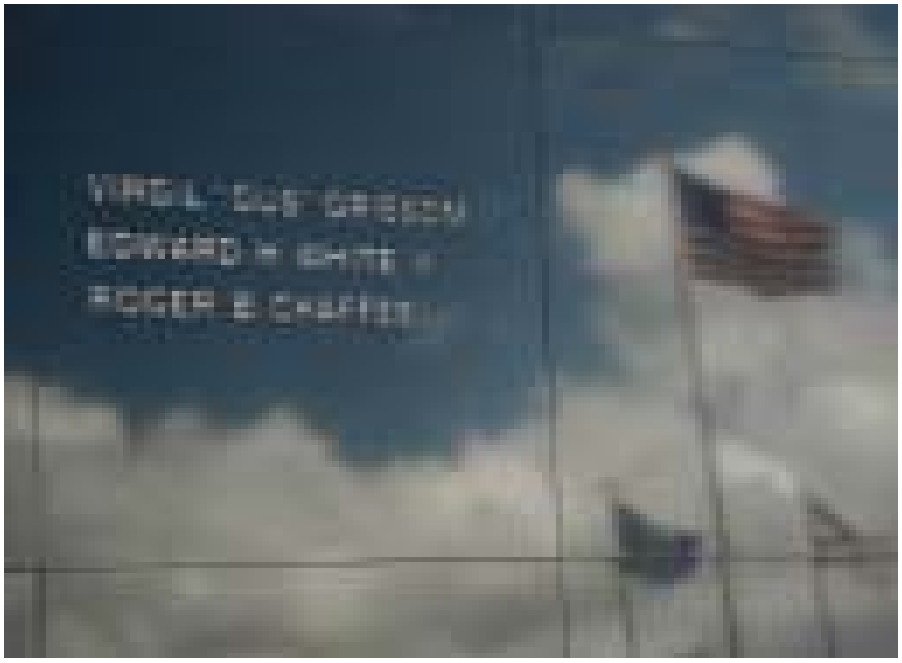
January History

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.

In January of 1967, after a successful 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 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 crew of STS-107. L to R: Brown, Husband, Clark, Chawla, Anderson, McCool, Ramon

The Columbia accident ultimately led to the decision to stop flying the space shuttle once the International Space Station was complete and to develop a safer manned vehicle.

January Nights

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

If you are out observing the open star clusters Pleiades or Hyades in 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.

Sunrise and Sunset

Sun	Sunrise	Sunset
January 1st (EST)	07:20	16:24
January 15th	07:18	16:48
January 31st	07:07	17:08

Astronomical and Historical Events

- 1st Distant flyby of Saturn's moons *Aegaeon*, *Pan*, *Pandora*, *Methone* and *Tethys* by the Cassini spacecraft
- 1st Apollo Asteroid 2015 LV24 near-Earth flyby (0.076 AU)
- 1st History: GRAIL-B spacecraft enters lunar orbit (2012)
- 1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, *Ceres* (1801)
- 2nd Last Quarter Moon
- 2nd Moon at Apogee (furthest distance from Earth)
- 2nd Earth at Perihelion, closest approach to the Sun (0.983 AU)
- 2nd Apollo Asteroid 2011 YP10 near-Earth flyby (0.074 AU)
- 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 Quadrantids meteor shower peaks; radiates from the constellation Boötes (name from an obsolete constellation called Quadrans Muralis)
- 3rd Mars Winter Solstice (Southern Hemisphere)
- 3rd Kuiper Belt Object 230965 (2004 XA192) at Opposition (34.657 AU)
- 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)

Astronomical and Historical Events (continued)

- 3rd History: Stephen Synnott discovers Uranus' moons *Juliet* and *Portia* (1986)
- 4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
- 5th Atira Asteroid 2012 VE46 closest approach to Earth (0.369 AU)
- 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 Apollo Asteroid 85990 (1999 JV6) near-Earth flyby (0.032 AU)
- 6th Aten Asteroid 2001 BB16 near-Earth flyby (0.045 AU)
- 6th Apollo Asteroid 2013 BC70 near-Earth flyby (0.087 AU)
- 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)
- 6th History: launch of Surveyor 7, the last of the unmanned Surveyor spacecrafts; soft-landed near Tycho crater (1968)
- 7th History: discovery and first recorded observations of Jupiter's four largest moons *Io*, *Europa*, *Ganymede* and *Callisto* by Galileo Galilei (1610)
- 8th Apollo Asteroid 2015 WE2 near-Earth flyby (0.058 AU)
- 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 New Moon
- 9th Second Saturday Stars – Open House at the McCarthy Observatory
- 9th Aten Asteroid 2014 BA3 closest approach to Earth (1.043 AU)
- 9th Centaur Object 32532 *Thereus* at Opposition (11.822 AU)
- 9th History: Voyager 2/Stephen Synnott discovers Uranus' moon *Cressida* (1986)
- 10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)
- 10th History: U.S. Army first bounces radio waves off the Moon (1946)
- 11th History: the Lunar Prospector spacecraft enters lunar orbit for a nineteen month chemical mapping mission (1998)
- 11th History: William Herschell discovers Uranus' moons *Titania* and *Oberon* (1787)
- 12th Aten Asteroid 2010 BB near-Earth flyby (0.080 AU)
- 12th Apollo Asteroid 4486 *Mithra* closest approach to Earth (2.017 AU)
- 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 5786 *Talos* closest approach to Earth (0.741 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 Moon at perigee (closest distance from Earth)
- 14th Distant flyby of Saturn's moons *Calypso*, *Enceladus*, *Mimas*, *Atlas*, *Daphnis* and *Telesto* by the Cassini spacecraft
- 14th Amor Asteroid 337866 (2001 WL15) near-Earth flyby (0.080 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 History: Stardust spacecraft returns samples of Comet P/Wild 2 (2006)

Astronomical and Historical Events (continued)

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 in almost five months of exploring the floor of the crater and its southern rim (1973)
16th First Quarter Moon
16th Flyby of Saturn's largest moon, *Titan*, by the Cassini spacecraft
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th Schedule launch of the Jason 3 ocean altimetry satellite from the Vandenberg Air Force Base, California
17th History: Pierre Mechain's discovery of Comet 2P/Encke (1786); short period comet that completes a circuit around the Sun every 3.3 years, named after Johann Encke who computed the comet's orbit, recognizing it as a periodic comet
19th Kuiper Belt Object 20000 Varuna at Opposition (42.814 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 developed by J.D. Titius, known as "Bode's Law" or "Titius-Bode Law" (1747)
20th History: Rich Terrile discovers Uranus' moons *Cordelia* and *Ophelia* (1986)
21st Apollo Asteroid 2011 BG24 near-Earth flyby (0.080 AU)
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 Apollo Asteroid 1685 *Toro* closest approach to Earth (0.157 AU)
22nd Plutino 208996 (2003 AZ84) at Opposition (43.827 AU)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd Full Moon
23rd Atira Asteroid 2007 EB26 closest approach to Earth (0.127 AU)
23rd Asteroid 2062 Aten closest approach to Earth (0.443 AU)
23rd History: Brad Smith discovers Uranus' moon *Bianca* (1986)
24th History: launch of space shuttle Discovery (STS-51-C); 100th human spaceflight to achieve orbit (1985)
24th History: discovery of the Martian meteorite Dhofar 019 in Oman (2000)
24th History: launch of Japan's Hiten spacecraft; first use of a low-energy transfer to modify an orbit and the first demonstration of a transfer to the Moon requiring no change in velocity for capture (1990)
24th History: flyby of Uranus by the Voyager 2 spacecraft (1986)
25th History: exploration rover Opportunity lands on Mars at Meridiani Planum; still operational and currently exploring Endeavour Crater (2004)
25th History: launch of the Infrared Astronomical Satellite (IRAS); first space telescope to survey of the entire sky at infrared wavelengths (1983)
25th History: launch of the U.S. Moon orbiter Clementine (1994)
25th History: Joseph Lagrange born (1736); mathematician who discovered five special points in the vicinity of two orbiting masses where a third, smaller mass can orbit at a fixed distance from the larger masses. The L1 Lagrange Point of the Earth-Sun system is the current home of the Solar and Heliospheric Observatory Satellite (SOHO).
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)

Astronomical and Historical Events (continued)

26th History: launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27th Apollo Asteroid 438661 (2008 EP6) near-Earth flyby (0.050 AU)
27th Apollo Asteroid 161989 *Cacus* closest approach to Earth (0.574 AU)
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 Apollo Asteroid 2015 VC2 near-Earth flyby (0.015 AU)
28th Aten Asteroid 2013 GM3 near-Earth flyby (0.064 AU)
28th Centaur Object 15504 (1999 RG33) at Opposition (15.286 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 History: Soviet spacecraft Phobos 2 enter orbit around Mars; successfully returned 38 images before contact was lost; its lander was not deployed (1989)
30th Moon at Apogee (furthest distance from Earth)
30th Distant flyby of Saturn's moons *Pan* and *Polydeuces* by the Cassini spacecraft
30th Aten Asteroid 2012 BX34 near-Earth flyby (0.067 AU)
30th Aten Asteroid 2015 AB44 near-Earth flyby (0.068 AU)
30th History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st Last Quarter Moon
31st History: launch of Apollo 14; third manned moon landing with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell (1971)
31st History: launch of Soviet Moon lander Luna 9; first spacecraft to land and to transmit photographs from the Moon's surface (1966)
31st History: launch of Mercury-Redstone 2 rocket with Ham the chimpanzee (1961)
31st History: launch of the first U.S. satellite, Explorer 1; detected inner radiation belt encircling the Earth (1958)

Commonly Used Terms

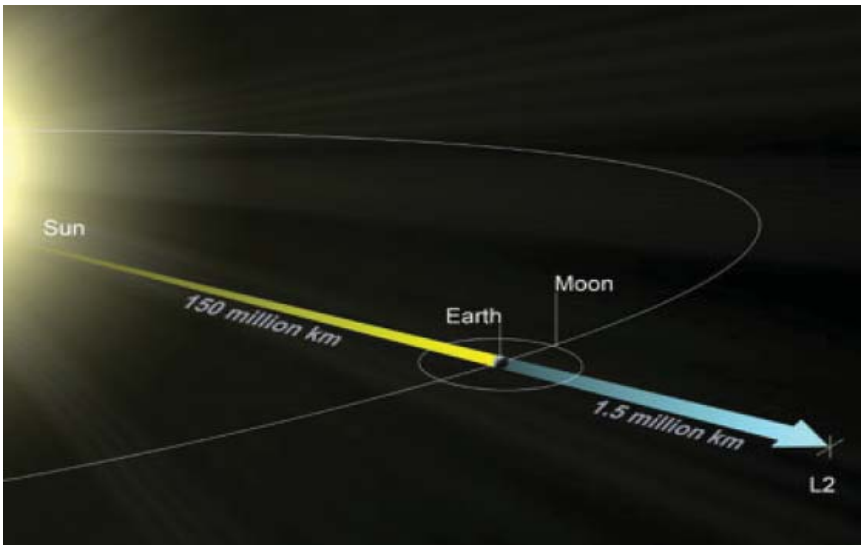
- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth's orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm's length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)

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).



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

International Space Station/Space Shuttle/Iridium Satellites

Visit *www.heavens-above.com* for the times of visibility and detailed star charts for viewing the International Space Station, the Space Shuttle (when in orbit) and the bright flares from Iridium satellites.

Solar Activity

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

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Page 1 design and graphic calendars: Allan Ostergren

Second Saturday Stars poster: Marc Polansky

Second Saturday Stars

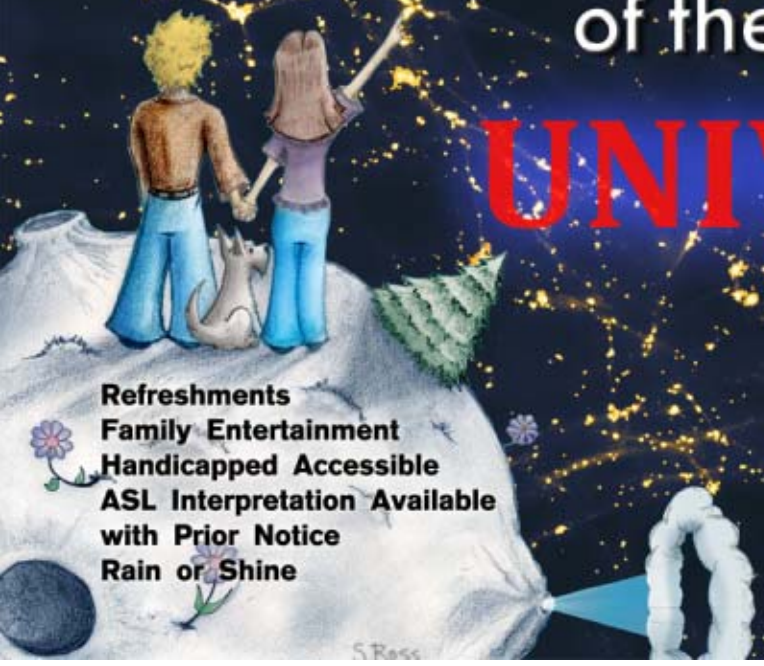
FREE EVENT

Every Month at the
John J. McCarthy Observatory
Behind the New Milford High School
860.946.0312
www.mccarthyobservatory.org

January 9th
7:00 - 9:00 pm

Learning the STRUCTURE

of the UNIVERSE

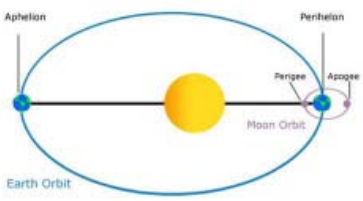
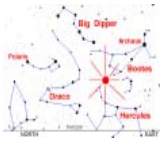
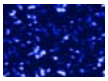
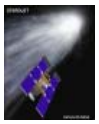
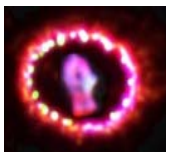


Refreshments
Family Entertainment
Handicapped Accessible
ASL Interpretation Available with Prior Notice
Rain or Shine

Map

January 2016

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
On January 2, Earth will be at Perihelion, its closest distance relative to the Sun. It will return to its farthest orbital position (Aphelion) on July 4th. The graphic on left shows Earth's orbit of the Sun, and at right compares the solar orbits of Earth, Mars and Mercury.  					1  Giuseppe Piazzi discovers Ceres, 1st asteroid, now dwarf planet (1801) GRAIL-B spacecraft enters lunar orbit (2012) 	2  Moon at perigee (closest distance to Earth) 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)	launch of Luna 21 and the Lunokhod 2 moon rover (1973) 8   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)  2nd Saturday Stars Open House McCarthy Observatory
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)	13 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)	discovery of the Martian meteorite SAU 090 in Oman (2002) 19   Launch of New 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 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)	Philibert Melotte discovers Jupiter's moon Pasiphae (1908) 27 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 Moon at apogee (furthest from the Earth) 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) Launch of Mercury-Redstone 2 rocket with Ham, the astrochimp (1961)						

Phases of the Moon