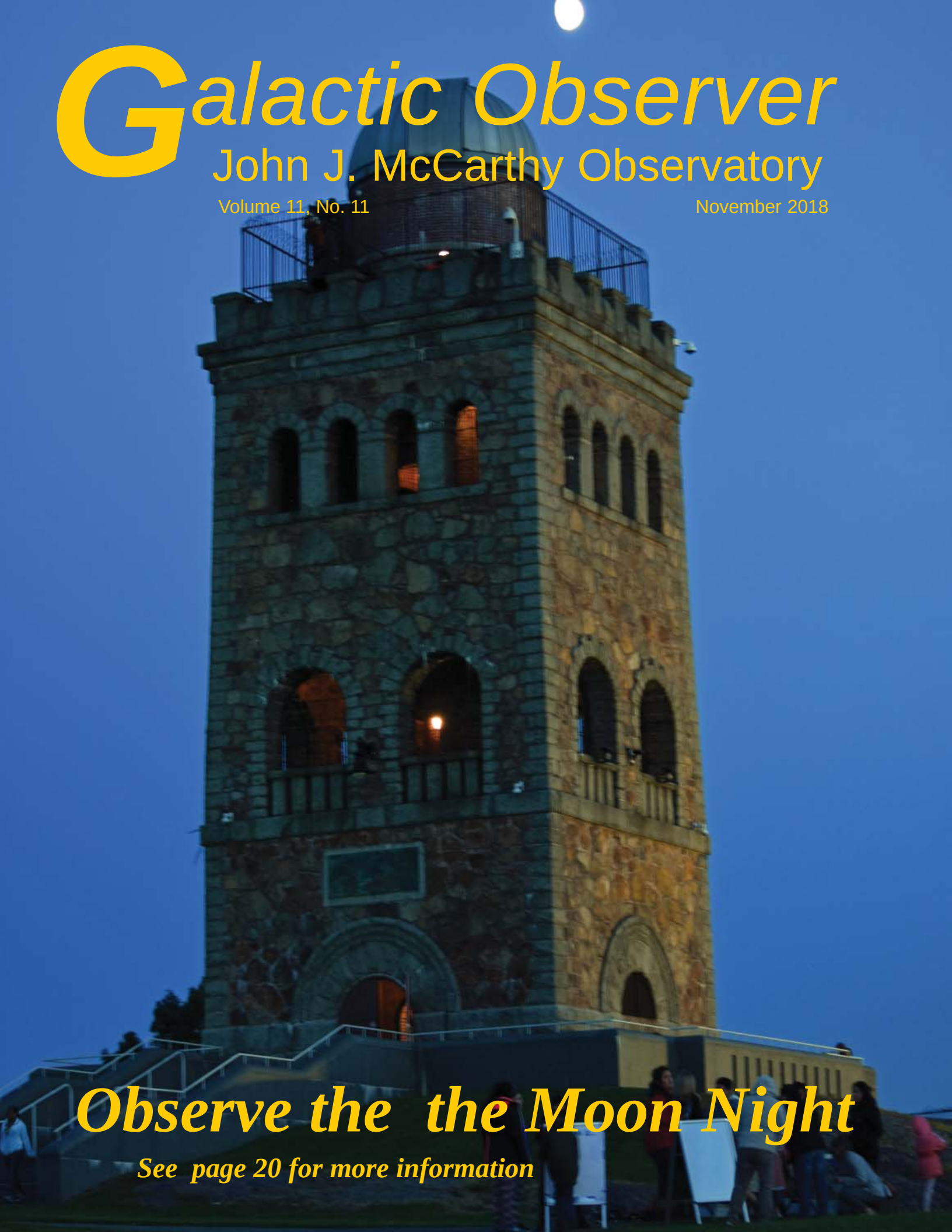
Galactic Observer

John J. McCarthy Observatory

Volume 11, No. 11 November 2018



Observe the the Moon Night

See page 20 for more information

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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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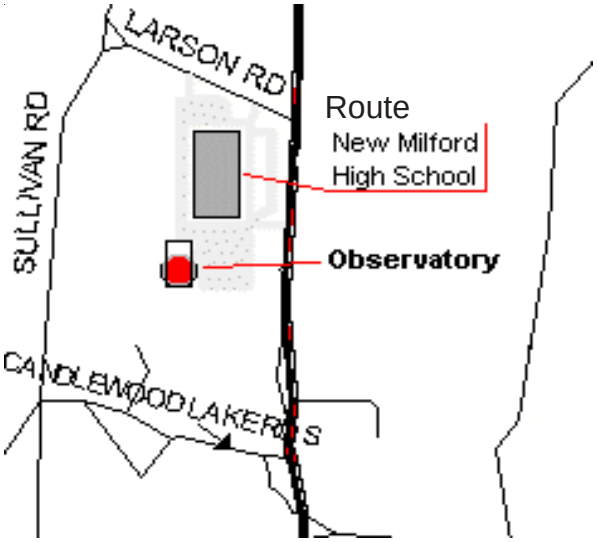
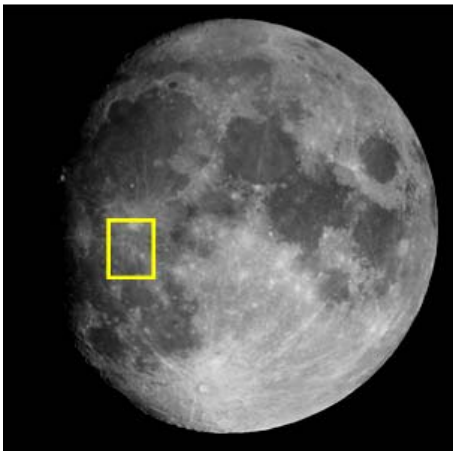


In This Issue

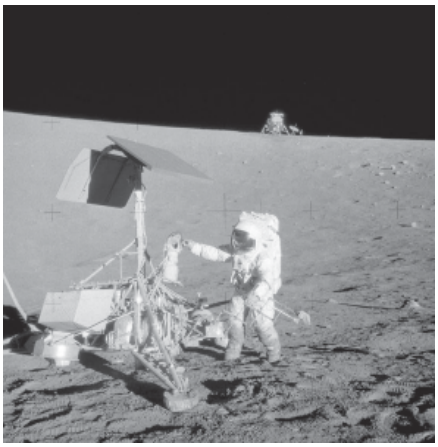
"Out the Window on Your Left"

IT'S BEEN OVER 45 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

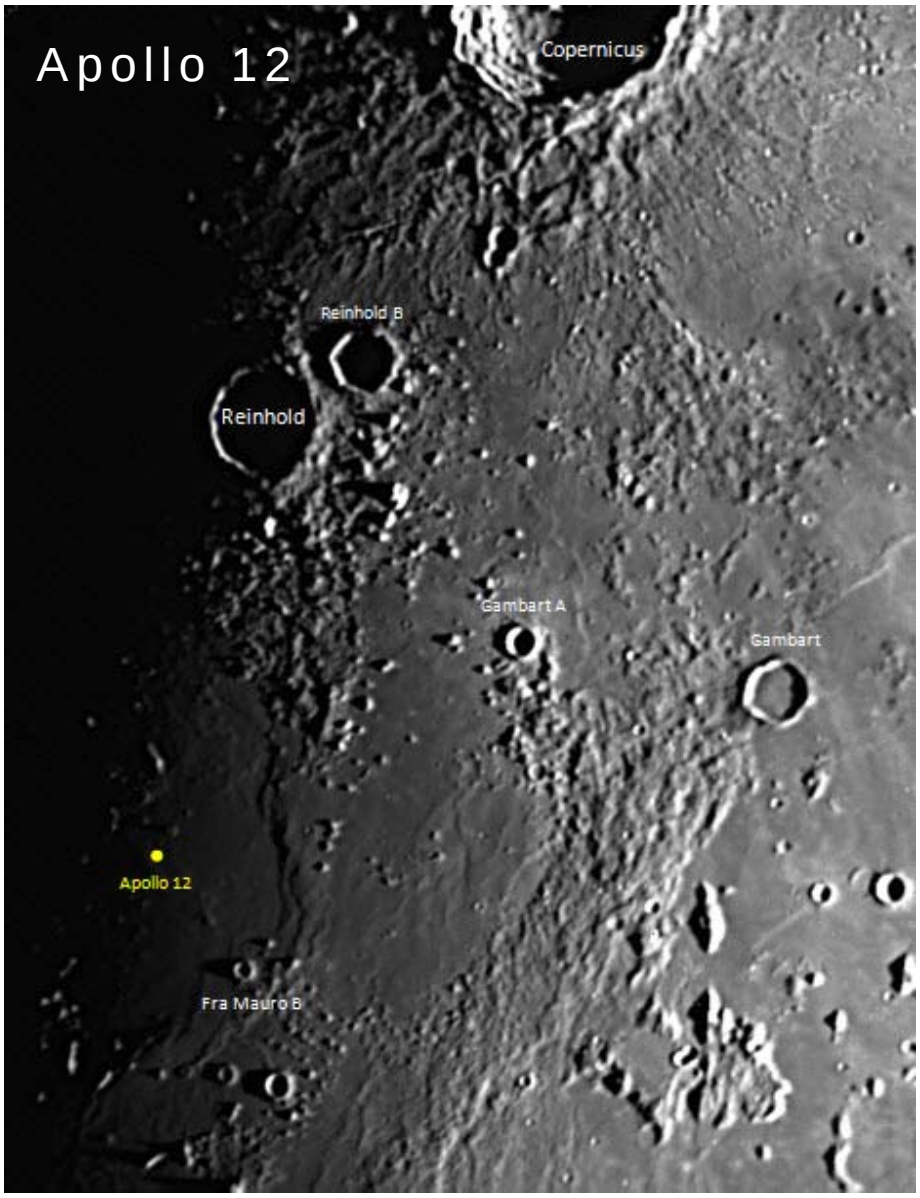


our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

The landing site of Apollo 12 is visible in this month's image. The site for the second Moon landing was approximately 930 miles (1,500 km) west of the Apollo 11 site and similar in that it offered a relatively smooth landing area. The Apollo 12 site was selected for its proximity to Copernicus crater, 190 miles (300 km) to the north and the ejecta that was believed to have covered the site from the crater's formation. The location was also home to Surveyor 3, an unmanned robotic spacecraft that landed on the Moon in April of 1967.



Astronaut Alan Bean inspects Surveyor 3. Credit: NASA



The crew of the Apollo 12 Lunar Module (Pete Conrad and Al Bean) executed a pinpoint landing on November 19, 1969, setting down 535 feet from the Surveyor spacecraft (to minimize the potential of contaminating the Surveyor spacecraft by the descent engine exhaust or from dust kicked up by the engine, the landing was required to be at least 500 feet away from Surveyor). The Sun was only 6° above the horizon at touchdown, casting long shadows across the volcanic plains and adding sharp relief to the geologic features at the landing site.

Conrad and Bean spent 7 hours and 45 minutes on the surface, in two separate excursions, collecting 75 pounds (34 kg) of rock and soil samples and setting up experiments. The astronauts were also able to venture into the crater in which Surveyor had landed and remove pieces (including the TV camera and soil scoop) for further study back on Earth.

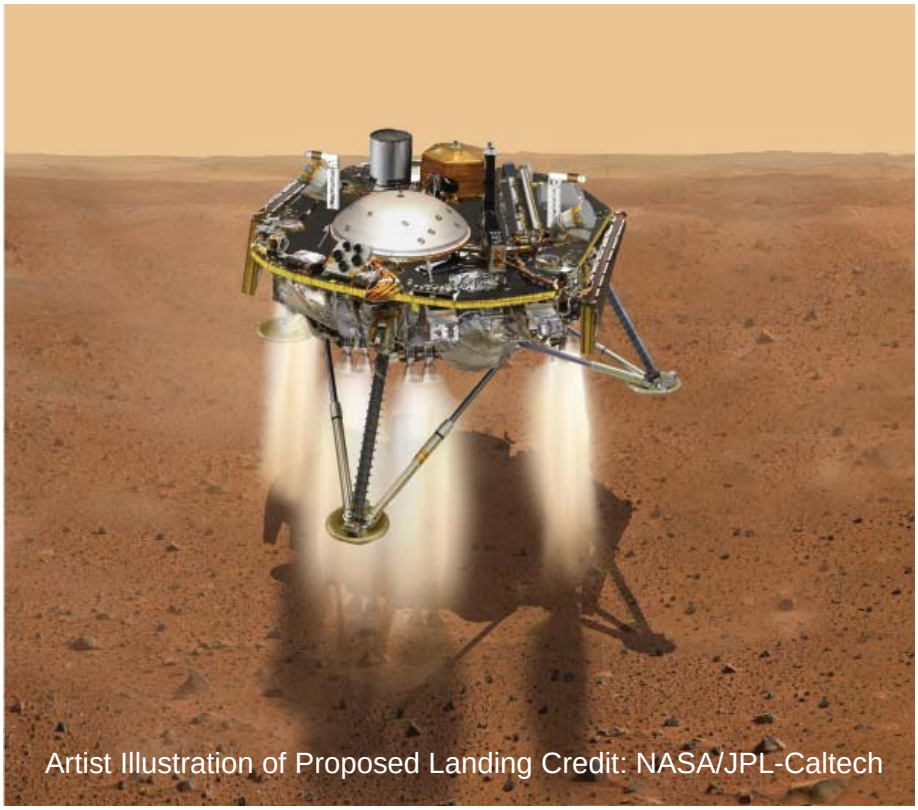
InSight

NASA's Discovery Program mission InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) was launched on May 5th from the Vandenberg Air Force Base in California aboard a United Launch Alliance Atlas V rocket. It was the agency's first interplanetary mission launched from the west coast. InSight is scheduled to land on Mars' Elysium Planitia, a relatively smooth plain in Mars' northern hemisphere, on November 26th at approximately 4 pm EST.

The 794 pound InSight lander is built on a platform similar to that used for the successful Phoenix mission that explored the planet's polar region, saving testing time and development cost. The lander is equipped with two science instruments, a seismometer and heat probe, as well as communication antennae for a radio science experiment. The seismometer will provide information on the nature of the planet's crust, mantle and core by detecting seismic waves (vibrations) generated from marsquakes, meteorite impacts or other events, as they pass through and interact with the planet's interior. The heat probe will burrow into the soil, up to a depth of 16 feet (5 meters), to measure the heat from the planet's interior and pinpoint its source. The lander's antennae will be used to precisely determine the planet's position in space as Mars orbits the Sun, and measure the planet's wobble about its axis. From this data, the size, composition and state (solid or liquid) of the interior can be inferred. The science from InSight is also expected to contribute to our understanding of the formation of other rocky and terrestrial planets.

InSight is equipped with a robotic arm that will remove the instruments and equipment from the lander's deck and place them on the ground. The arm is also equipped with a camera which will survey the area around the landing site for optimal instrument placement. This will be the first time that a robotic arm will be used for this purpose (moving instruments and equipment into position on another world).

The InSight spacecraft was launched with two CubeSats, called Mars Cube One (MarCO). The miniature spacecrafts are trailing behind InSight and will be in position to monitor InSight's decent and landing onto the Red Planet (being equipped with high-gain antennas, radios and color cameras). Although not vital to mission performance (NASA's Mars orbiters will be used for data relay), MarCO success could benefit future missions to other places in the solar system where such assets are not available.



Artist Illustration of Proposed Landing Credit: NASA/JPL-Caltech

Apollo 7 Anniversary

Fifty years ago, on October 11, 1968, Apollo 7 lifted off from what is now the Cape Canaveral Air Force Station, atop a Saturn 1B rocket. It was the first manned flight since the Apollo 1 pad fire on January 27, 1967 in which three astronauts were lost. The flight was designed to qualify an Apollo Command and Service Module in low-Earth orbit that had undergone extensive design changes since the fire. For example, the three-piece, unwieldly main hatch in Apollo 1 that required the pressure to be equal on both sides, pieces to be brought into the spacecraft, and 60 to 90 seconds to egress under the best conditions was changed to a one-piece (unified) hatch with a pressurized gas, quick-release which opened outward in 3 seconds and allowed the crew to egress in less than 30 seconds.

Commander Wally Schirra (Mercury 8) and rookies Command Module Pilot Donn Eisele and Lunar Module Pilot Walt Cunningham made up the three-man Apollo crew. Objectives of the

eleven-day mission included the field testing of spacecraft systems - in particular, the Service Module's engine which would be used to place the spacecraft in lunar orbit and back out of lunar orbit for the trip home on future missions. All eight firings of the Service Module's engine were successful, with the final firing used to slow the spacecraft for re-entry.

Eisele also practiced a simulated docking with the rocket's second stage, required on a lunar mission to extract the Lunar Module from the adapter atop the Saturn V's third stage.

The Apollo 7 flight took place approximately one month after the Soviets had launched an unmanned Zond 5 spacecraft with a number of diverse biological specimens. Zond 5 became the first spacecraft to circle the Moon and return safely to Earth. The spacecraft's occupants survived the ordeal despite a rough landing. It was widely viewed as a precursor to a manned lunar mission. The success of the Apollo 7 mission, and the Soviet progress, pressed NASA Administrator James Webb to publicly announce a change in the flight profile for Apollo 8, from a low-Earth orbit check flight to one that would orbit the Moon.

50th Anniversary Coins

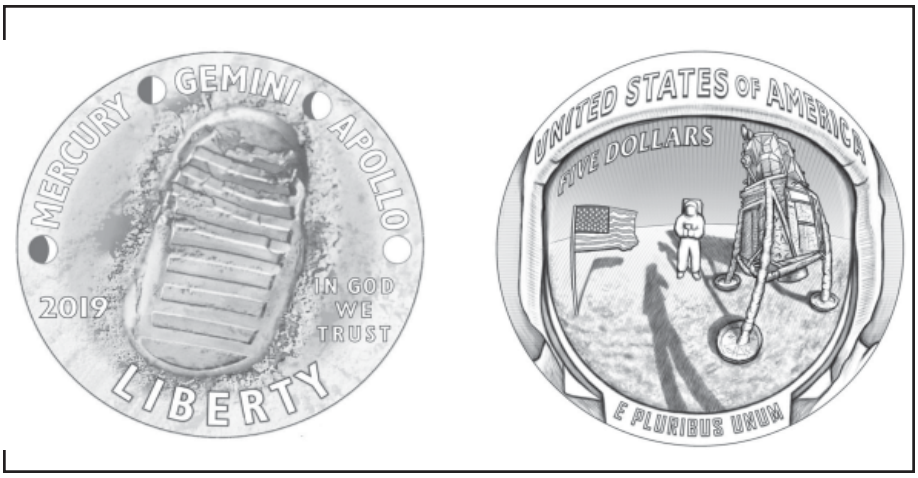
On the 50th anniversary of the flight of Apollo 7, the U.S. Mint unveiled the design to be struck on the head side of the coins which will commemorate next year's 50th anniversary of the Apollo 11 landing on the Sea of Tranquility in 1969. The coins will be issued in 2019 in gold, silver (two sizes) and clad metal.

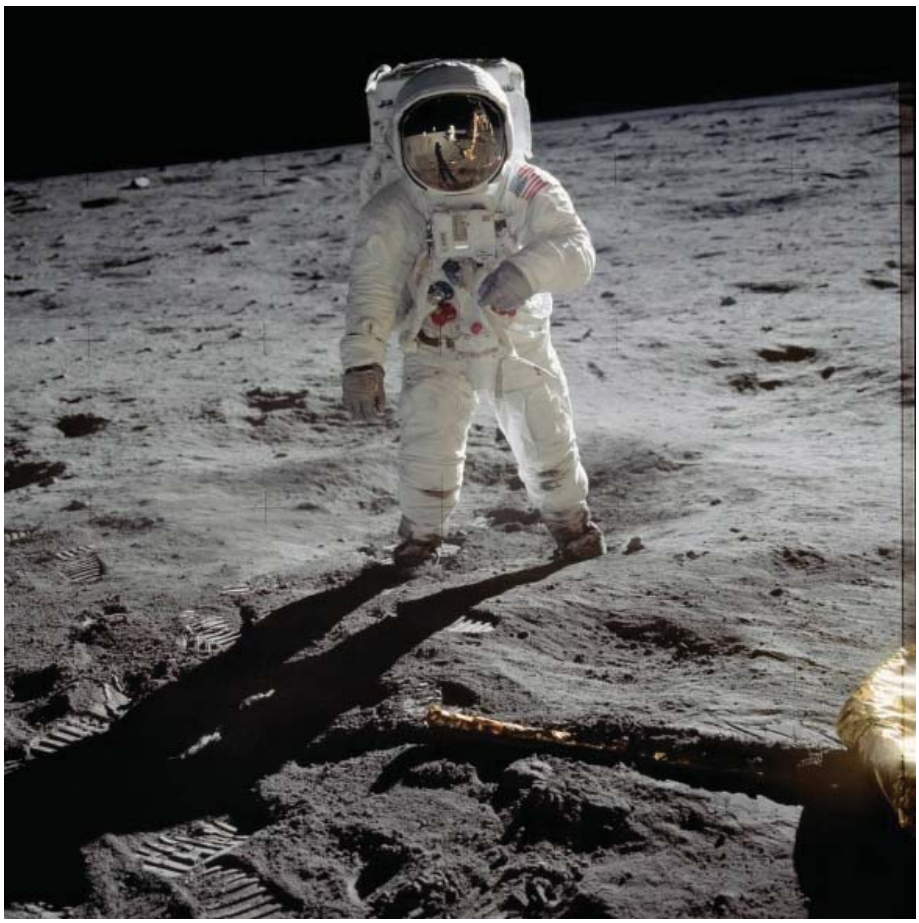
The concave-shaped head side will feature a design by artist Gary Cooper of Belfast, Maine, the winning design in the Apollo 11 Commemorative Coin Design Competition, as selected by the Secretary of the Treaury. The design was fashioned by sculptor-engraver Joseph Menna.

Congress authorized the commemorative coin program in Public Law 114-282, specifying the curved form ("to more closely resemble the visor of the astronaut's helmet of the time") and the design on the coin's convex tail side ("close-up of the famous 'Buzz Aldrin on the Moon' photograph taken July 20, 1969, that shows just the visor and part of the helmet of astronaut Buzz Aldrin … and reflects the image of the United States flag and the lunar lander …"). Neil Armstrong, who took the photo, can be seen in the center of the reflection. Mint sculptor-engraver Phebe Hemphill designed and sculpted the tails side. The Treasury Secretary was directed to hold "a juried, compensated competition to determine the design of the common" head side of the coin with the "design being emblematic

of the United States space program leading up to the first manned Moon landing.

The purchase price of the coins will include a surcharge - $35 per coin for the 0.850 inch $5 gold coin, $10 per coin for the 1.50 inch $1 silver coin, $5 per coin for the 1.205 inch half-dollar clad coin, and $50 per coin for the 3 inch $1 silver coin. Proceeds from the sales of the coins (surcharges) will go towards the Smithsonian Institution's National Air and Space Museum's "Destination Moon" exhibit, "for design, education, and installation costs related to establishing and maintaining the exhibit, and for costs related to creating a traveling version of the exhibition" (50%); the Astronauts Memorial Foundation, "for costs related to the preservation, maintenance, and enhancement of the Astronauts Memorial and for promotion of space exploration through educational initiatives" (25%); and to the Astronaut Scholarship Foundation, "to aid its missions of promoting the importance of science and technology to the general public and of aiding the United States in retaining its world leadership in science and technology by providing college scholarships for the very best and brightest students pursuing degrees in science, technology, engineering, or mathematics (STEM)" (25%). A total sell out of the commemorative coins could raise in excess of $14.5 million for the three organizations.





Astronaut Buzz Aldrin near one of the footpads of the lunar module Eagle. Neil Armstrong took this photograph with a 70 mm lunar surface camera on July 20, 1969. Credit: NASA

Parker Solar Probe - Status Report

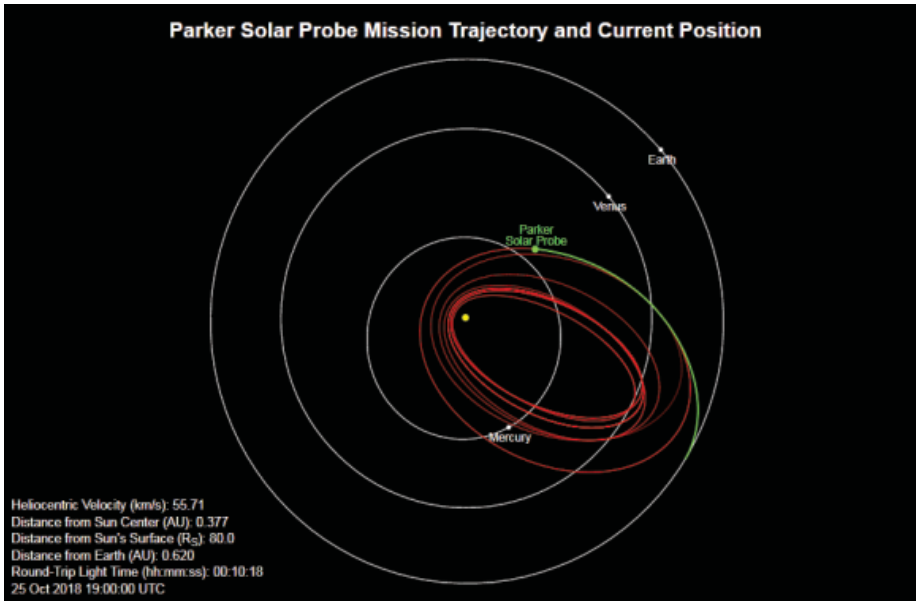
The Parker Solar Probe completed its first flyby (of seven total flybys) of Venus on October 3, 2018. The encounter was used to slow the spacecraft's velocity (by 10 percent) and alter its trajectory (bringing it closer to the Sun by 4 million miles or 6.4 km). Future gravity assists will eventually bring the spacecraft to within 3.83 million miles or 6.1 km of the Sun's photosphere (seven times closer than the previous record). At closest approach, the spacecraft will be moving at approximately 430,000 miles per hour (692,000 km/hr).

The crossing of Venus' orbit triggered other changes in the spacecraft's configuration as the temperature started to increase (on October 5th, the distance from the Sun dropped below 65 million miles or 105 million km). The two solar array wings on the spacecraft are designed to tilt inward, away from the Sun and behind the spacecraft's Sun shield, as it

approaches the Sun and temperatures exceed 150° F, or 65° C. Fixed arrays would eventually overheat and degrade, so the spacecraft's controller monitors the temperature and adjusts the angle of the arrays accordingly. Controlling the arrays is a fine balancing act, as too much angle or shade can starve power production - too little and the arrays overheat.

The spacecraft can further decrease array temperature by pumping water through channels in the array and using radiator panels located in the shadow of the thermal protection system (solar shield) to reject the damaging heat to space.

The spacecraft is currently heading for its first close encounter (perihelion) with the Sun on November 5th. Mission goals include tracing the flow of energy that heats the solar corona and accelerates the solar wind, determining the organization and dynamics of the Sun's plasma and magnetic fields, and exploring the means by which energetic particles are accelerated throughout the solar system (generating space weather).



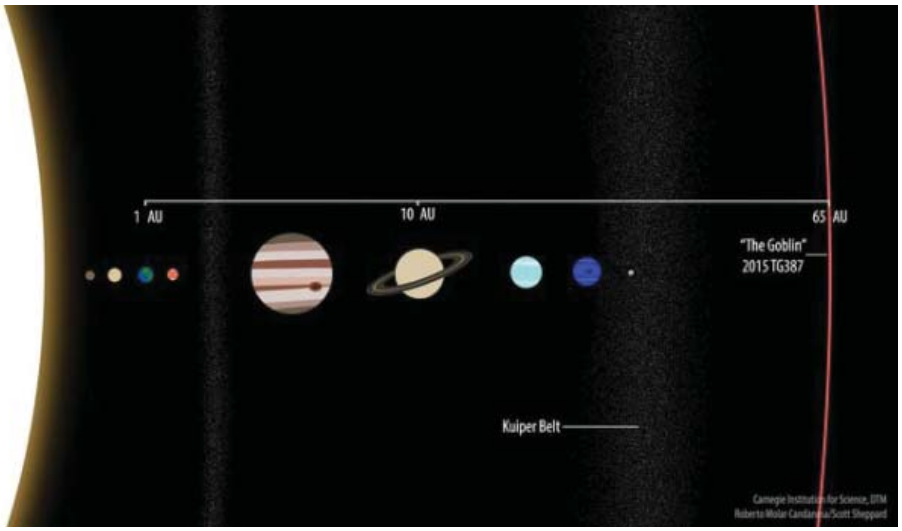
New Dwarf Planet

The Carnegie Institution for Science and the International Astronomical Union's Minor Planet Center have announced the discovery of a new dwarf planet (2015 TG387). The distant world is approximately 186 miles (300 km) in diameter (assuming a moderate albedo or reflectivity) and has a highly elongated orbit with an orbital period of 40,000 years. Dubbed the "Goblin" after the month in which it was first discovered (October), the diminutive realm never gets closer than 65 AU (6 billion miles or 9.7 billion km) to the Sun. At its greatest distance, the Goblin is more than 213.8 billion miles (344 billion km) away.

A team of astronomers, led by Scott Sheppard from Carnegie, Chad Trujillo from Northern Arizona University, and David Tholen from the University of Hawaii, discovered the Goblin at a distance of 80 AU (7.4 billion miles or 12 billion km) using the Subaru 8-meter (26 feet) telescope on Mauna Kea, Hawaii. Follow-up observations were made over the past three years by telescopes at the Las Campanas Observatory, Chile, and the Discovery Channel Telescope in Happy Jack, Arizona.

Sheppard's team believes that the orbit of the Goblin, along with the elongated orbits of several other distant worlds in the same region (for example, 2012 VP113 and Sedna) strengthens the case for a yet-to-be-discovered "Planet X" that acts as a cosmic shepherd. Assuming that the grouping of these distant worlds is not a random happenstance and therefore influenced by a guiding force, this mysterious shepherd world is hypothesized to be approximately 10 times the mass of the Earth, with an orbit between 200-700 AUs from the Sun.

Currently Planet X only exists in mathematical proofs (Caltech



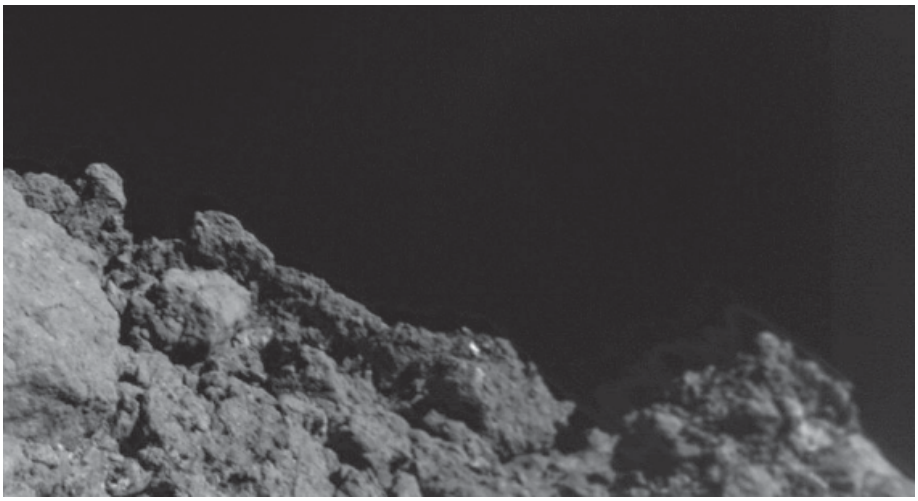
astronomers Konstantin Batygin and Mike Brown predicted the existence of the gas giant in 2015 based upon computer simulations). With such an elongated orbit, its discovery will have to wait until the illusory world comes within reach of our most powerful telescopes.

Hayabusa 2 and MASCOT

Shortly after midnight on September 21st (EDT), Japan's Hayabusa 2 spacecraft dropped down to within 180 feet (55 meters) of the surface of the asteroid Ryugu, releasing two tiny robotic rovers, MINERVA-II 1A and MINERVA-II 1B. Both rovers landed successfully and were able to transmit data and photos from the surface.

On October 2nd, a small European-built lander, called MASCOT (Mobile Asteroid Surface Scout), was deployed, slowly freefalling 200 feet (60 meters) over a six minute period to a site in Ryugu's southern hemisphere (named "Alice in Wonderland" by the mission team). After bouncing several times, MASCOT was able to right itself using its motorized swinging arm and positional sensors. The box-shaped rover, measuring less than a foot across, spent 17 Earth-hours, or 3 asteroid days, analyzing the surface of the asteroid from three difference locations until its battery was exhausted (MASCOT used its swinging arm to launch itself in the asteroid's almost non-existent gravity [1/66,500th of the Earth's] to a new location several yards (meters) away).

MASCOT used its wide-angle camera to photograph the landing site(s) and record the topography. A magnetometer recorded the strength of the asteroid's magnetic field and a radiometer recorded its

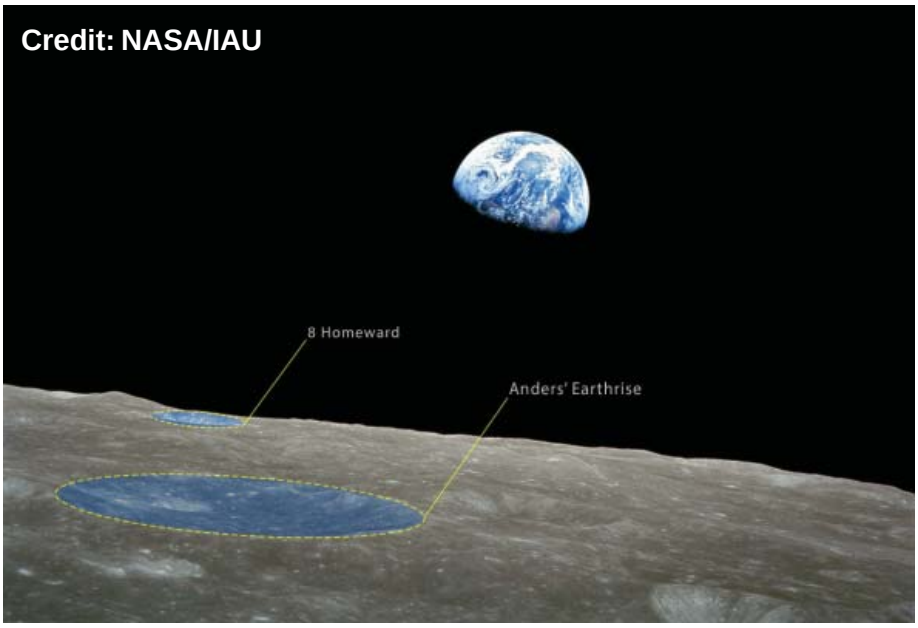


surface temperature. Chemical composition was analyzed by MASCOT's infrared spectrometer. What scientists didn't find was a lot of loose material or dust on the surface - the surface of Ryugu was covered with blocks of rock and boulders.

Ryugu is a carbonaceous asteroid (C-type). The majority of asteroids (75%) are classified as carbonaceous (carbon-rich, dark, and depleted in hydrogen, helium, and other volatiles). They are believed to have formed four-and-a-half-billion years ago during solar system formation. The Murchison meteorite (Australia) is believed to be similar in composition - an assumption that may have to be revisited once MASCOT data is available. Ryugu is also one of 17,000 known near-Earth asteroids, and is classified as potentially hazardous with an Earth-crossing orbit.

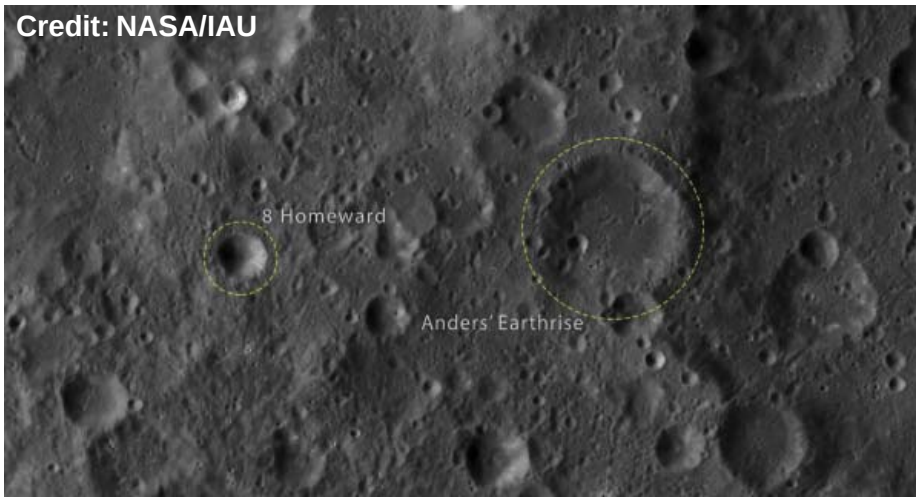
Apollo 8 Belated Accolades

On Christmas Eve, 1968, the crew of Apollo 8 was orbiting the far side of the Moon when the Earth appeared on the limb. Astronaut Bill Anders captured the first "Earthrise" with 70-millimeter color film camera. The iconic image has been reproduced on the covers of magazines, books, newspapers and even a postage stamp. As one of the most celebrated photos of the mission, and possibly the Apollo program, the image



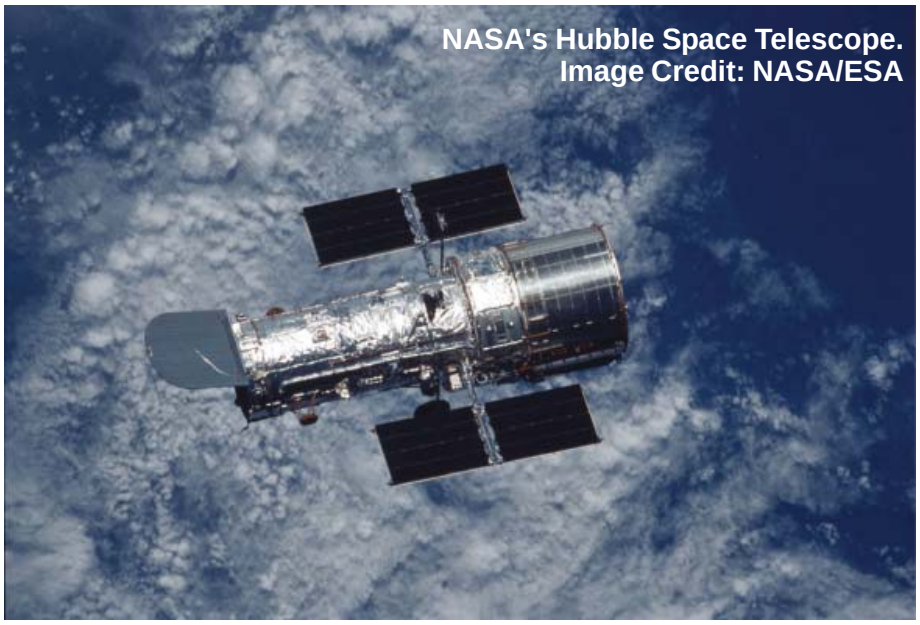
captured the imagination of the public and the environmental movement. Bill Anders perhaps said it best - "We came all this way to explore the Moon, and the most important thing is that we discovered the Earth."

After 50 years, the Working Group for Planetary System Nomenclature of the International Astronomical Union (IAU) approved new names for two of the craters seen in the foreground of the "Earthrise" image: "Anders' Earthrise" and "8 Homeward." "Anders' Earthrise," previously designated "Pasteur T", is 25 miles in diameter (40 km). The crater "8 Homeward" is only 8 miles across (12.5 km) and was originally designated "Ganskiy M. It is intended to denote the safe return of the Apollo 8 astronauts.



Aging Space Observatories

NASA's orbiting observatories are showing their age. The Kepler Space Telescope is currently offline and running out of fuel. The Hubble Space Telescope has been in operation for more than 28 years and Chandra X-Ray Observatory for more than 19 years. Both observatories recently suspended science operations and automatically entered a safe-mode (stable configuration), although Chandra was quick to return to normal operations.

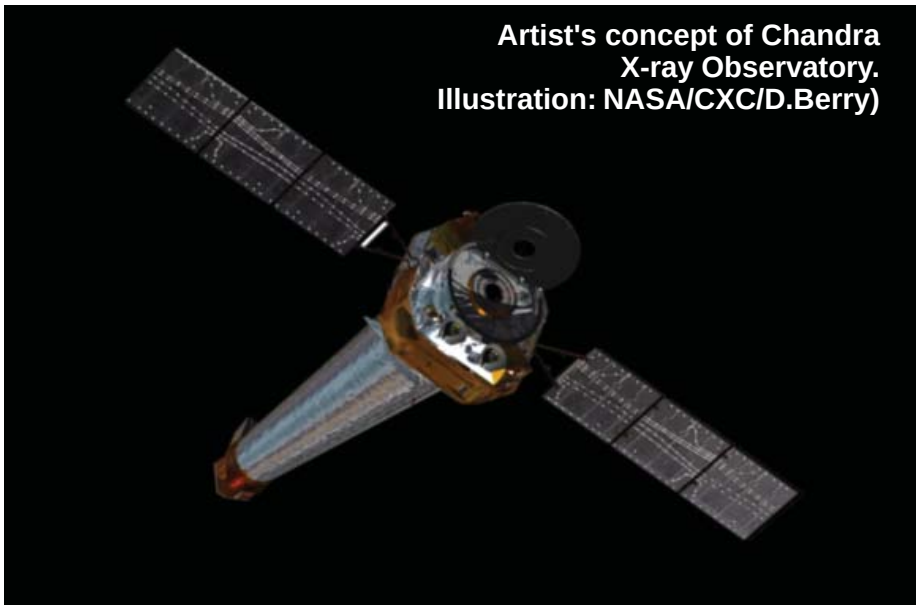


Hubble entered a safe mode on October 5th after a gyroscope failure (under normal operations, it uses its three gyroscopes to measures the speed at which the telescope is turning). Initial efforts to bring a backup gyroscope into service were not successful. However, after two weeks of exercising the backup gyroscope (for example, turning power off and then back on, changing modes and executed various maneuvers), the startup glitches appeared to have cleared.

The telescope is managed by and operated from NASA's Goddard Space Flight Center in Greenbelt, Maryland. It completes an orbit of the Earth every 97 minutes (at 5 miles or 8 km per second), making tracking and focusing on distant objects challenging, at best. The spacecraft uses its gyroscopes (like a compass), Fine Guidance Sensors (which lock on target stars), and reaction wheels (to move) in maintaining control and staying on mark over long observing campaigns. During the last Servicing Mission in 2009, astronauts installed six new gyroscopes - three have failed over the past nine years.

The Hubble operations team was able to bring the observatory back into service with three gyroscopes (including the backup) on October 26th. The telescope has already completed its first science observation (on October 27th), approximately three weeks after going in safe mode. With future failures inevitable, the spacecraft can be reconfigured for one gyroscope operations.

The Chandra X-ray Observatory entered a safe mode on October 10th after the spacecraft experience an anomaly that likely involved a gyroscope. The telescope was returned to normal science operations five days later after the Operations team was able to understand what triggered the automatic shutdown and identify the root cause as a packet of bad data which led the onboard computer to incorrectly calculate the spacecraft's momentum.

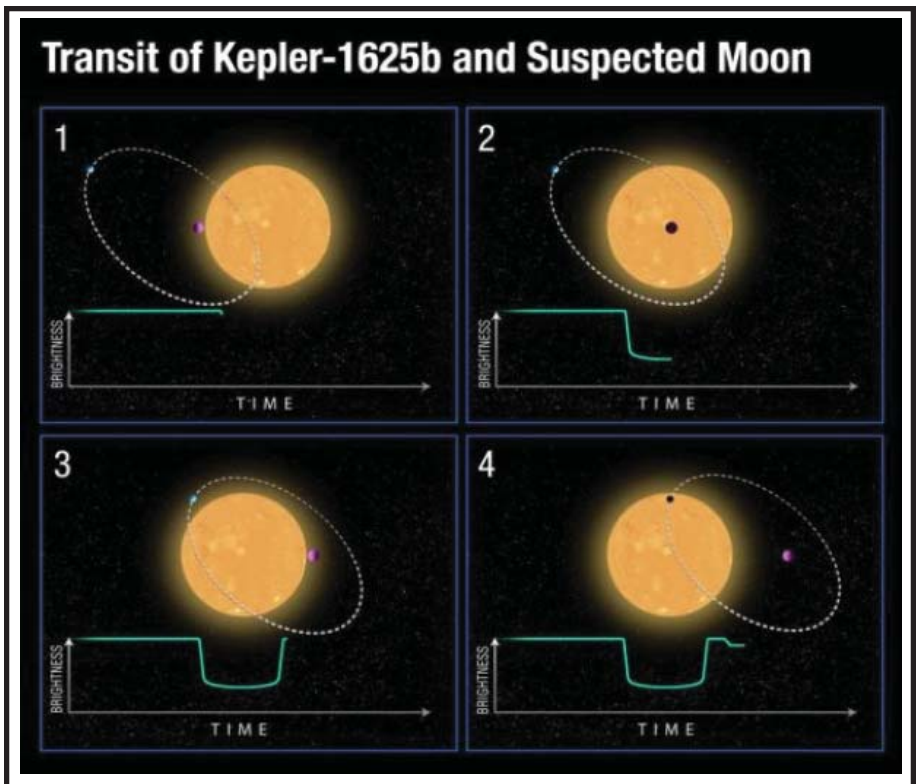

Artist's concept of Chandra X-ray Observatory. Illustration: NASA/CXC/D.Berry)

NASA is optimistic that both the Hubble and Chandra will be operational when the James Webb telescope launches in 2021 for joint observing campaigns. The Webb will operate primarily in the infrared part of the electromagnetic spectrum, complementing Hubble's capabilities in the ultra-violet and visible and Chandra in the x-ray parts of the spectrum. Webb's larger mirror and ability to go deeper into the infrared will allow astronomers to look back to the very beginning of the universe and galaxy formation.

Exomoon

In 2017, astronomers found signs of a possible moon orbiting an exoplanet around the star Kepler-1625 from the data collected by NASA's Kepler Space Telescope. The moon, if confirmed, would be the first discovered outside our solar system.

The host planet, Kepler-1625b, is a gas giant, several times more massive than Jupiter, and the only planet that has been detected around its parent star. The exoplanet orbits a solar-mass star at a distance equivalent to that of the Earth and Sun, at the inner edge of the habitable zone when liquid water could exist. The moon is unusually large (as compared to its host planet), approximately that of Neptune.



Sequence of Hubble Space Telescope photometric observations of the planet Kepler 1625b (purple object) and the planet's exomoon (smaller green object) . Image: NASA, ESA, D. Kipping (Columbia University), and A. Feild (STScI)

Two astronomers from Columbia University in New York have since used NASA/ESA's Hubble Space Telescope to observe Kepler-1625b, approximately 8,000 light years away. The exoplanet was monitored before and during its 19-hour transit in front of the star (transits of planets produce a small, but measurable, decrease in the star's brightness). Hubble observations detected a second and much smaller decrease after the

initial transit had concluded, consistent with a trailing moon.

The second dimming could also be from another planet; however, no other planets were detected by Kepler. While the Hubble data is compelling, additional observations are needed to fully corroborate this very unique discovery. Unlike Earth's moon that is hypothesized to have formed from the collision of rocky worlds, Kepler-1625b-i, as the moon is designated, is gaseous (much like its host planet), and therefore unlikely to have been created from a collision. If confirmed, planetary astronomers will need to find a new niche in their evolutionary models of planetary formation and "double planets."

Grand Finale Science

Although NASA/ESA's Cassini mission officially ended more than a year ago on September 15, 2017 with the destruction of the spacecraft, analysis of the data collected from 13 years of exploring the Saturnian system is still providing new insights into the gas giant, its rings and moons. The final twenty-two orbits that culminated in the spacecraft's fiery demise provided scientists their first close look at the planet's 1,200 mile (2,000 km) wide gap between the rings and Saturn's upper atmosphere. Science gained from the gap transits is now being published by several teams of researchers (six papers were included in the October 5th issue of the journal Science). Some of the findings are discussed below.

Flybys of Saturn by the Pioneer 11, and Voyager 1 and 2 spacecrafts suggested that water (the primary constituent of Saturn's rings) was migrating (raining) onto the upper layers of the planet's atmosphere. Cassini, in its gap transits, did detect molecular hydrogen. It also found methane, ammonia, molecular nitrogen, carbon monoxide, carbon dioxide and fragments and nanoparticles of organic materials in the "rain." The organics, identified and measured by Cassini's Ion Neutral mass Spectrometer, are attributed to the fragmentation of icy, organic-rich grains in the instrument's ante-chamber, due to the spacecraft's high velocity (19 miles/sec or 31 km/sec) relative to the planet's atmosphere. This organic rain is modifying the chemistry of the planet's upper atmosphere that we observe. The composition of the organics found in the ring rain was different than that found on Saturn's moons Enceladus and Titan, suggesting that there are, at least, three discrete sources of organic materials.

Saturn in 2018 from Earth (distance of approximately 1 billion miles or 1.4 billion km). Credit: NASA/ESA Hubble Space Telescope.

The mass of the material falling into the planet likely requires replenishment of the inner D-ring by material from the outer C-ring. The mass flow rate is important in our understanding of the age, evolution and lifetime of the rings. The Cassini data intimates from the ring mass that the rings are relatively new, having formed within the last 100 million years. Ring material is hypothesized to have been created from the collision of small moons due to long-term orbit instability. Questions remain on how this material, produced by the collision(s) could have migrated into the ring geometry we see today. If the rings are relatively young, we, as observers, live in a special time as the rings will darken and fade as time goes by.

Scientists were also able to build a profile of the dust grains in the rings (comprised of silicates, organics and nanophase hematite) raining down on the planet using the spacecraft's Cosmic Dust Analyzer instrument. The data collected over the 22 transits of the gap showed the highest concentration of dust grains within a few hundred miles (km) of the ring plane. Saturn's magnetic field was found to play a role in the distribution of the rain, with particles picking up an electric charge spiraling into the planet along the field lines. One of the more puzzling discoveries was that the silicate content of the raining

grains was higher than the bulk content of the entire ring system. Grain size was also smaller than expected, suggesting that larger particles are subject to an ongoing process of annihilation within the rings.

Cassini's close encounters allowed scientist to measure the alignment of the planet's magnetic field much more accurately. Conventional theory requires an offset between the planet's spin axis and magnetic field axis to maintain the magnetohydrodynamic dynamo process. Previous flybys had indicated that the two axes were closely aligned, a finding confirmed by Cassini's magnetometer. The axis symmetry (within 0.01°) may require physicists to reexamine conventional thinking of planetary dynamos.

The mission's Grand Finale provided an opportunity for Cassini's Magnetosphere Imaging Instrument to chart a newly discovered radiation belt. The belt extends from the top of Saturn's atmosphere to a ringlet (designated D73) in the D-ring. Another, interior ringlet (D68) separates the belt's charged particles into two groups. The particles are primarily protons, believed to have been released through the interaction of galactic cosmic rays and material in Saturn's rings.

The Juno spacecraft arrived at Jupiter during the final phase of Cassini's exploration of Saturn. With two gas giants under simultaneous observation, comparison was inevitable. Juno found that Jupiter's weather layer and jet streams extend deep into the atmosphere (likely as deep as 1,900 miles or 3,000 km) and contain about one percent of Jupiter's mass. Cassini's observations, by comparison, indicate a much deeper weather pattern (many thousands of miles). Despite being almost twice as far from the Sun as Jupiter, Saturn's weather dynamics may be related to its axial tilt (26.7° for Saturn vs. 3.1° for Jupiter) which would produce seasonal heating and drive atmospheric circulation.

The Cassini-Huygens mission was a cooperative project of NASA, ESA (European Space Agency) and the Italian Space Agency. The spacecraft spent 13 years in orbit around Saturn and generated a plethora of data that is still being analyzed.

Leonid Meteor Shower

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

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

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

What can we expect this year? Expect to see an average of 15-20 meteors per hour during the peak period from a dark site (as long as the skies are clear). A waxing gibbous moon (less than two days after first quarter phase) will be setting shortly after midnight on the 17th, providing dark skies for meteor watchers and early risers.

Danger: Space Debris

Estimates for the mass of material that falls on Earth each year range from 37,000-78,000 tons. Most of this mass would come from dust-sized particles and disintegrate in the Earth's atmosphere. The moon is not so fortunate; the lunar surface is continually modified by the

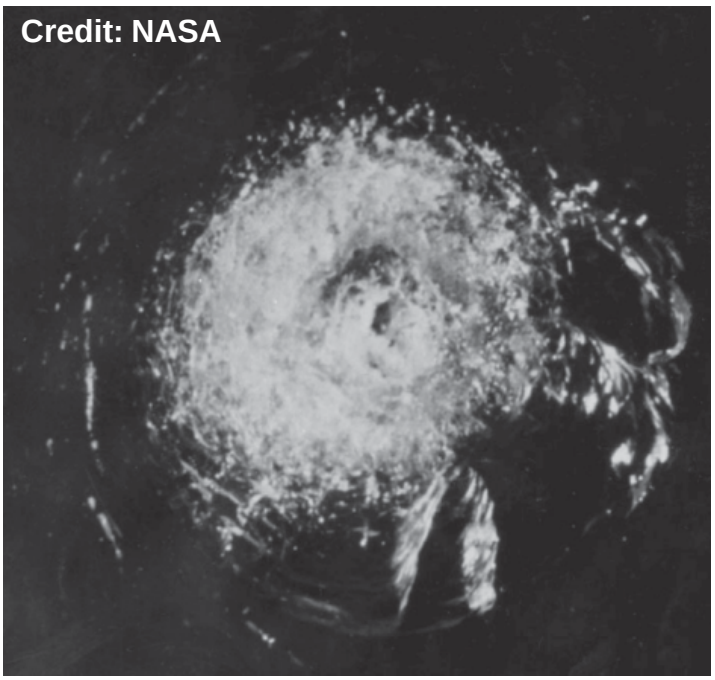
bombardment, as shown by the samples brought back from there by the Apollo astronauts. NASA is supporting projects that monitor the frequency of lunar impacts, anticipating that the information will be useful in designing more robust lunar structures and contingency plans for astronauts venturing out on the lunar surface.

NASA launched the Chandra X-ray Observatory in July 1999, placing it in an elliptical orbit that extends almost one-third the distance to the moon. In November 2003, the telescope's operators placed the telescope in a safe configuration during its passage through four meteor shower streams. Despite an extremely low probability (one in a million) that the telescope would be hit by a meteoroid, that's what apparently happened early on the morning of November 15th. Fortunately, there was no apparent damage to the more sensitive parts of the telescope.

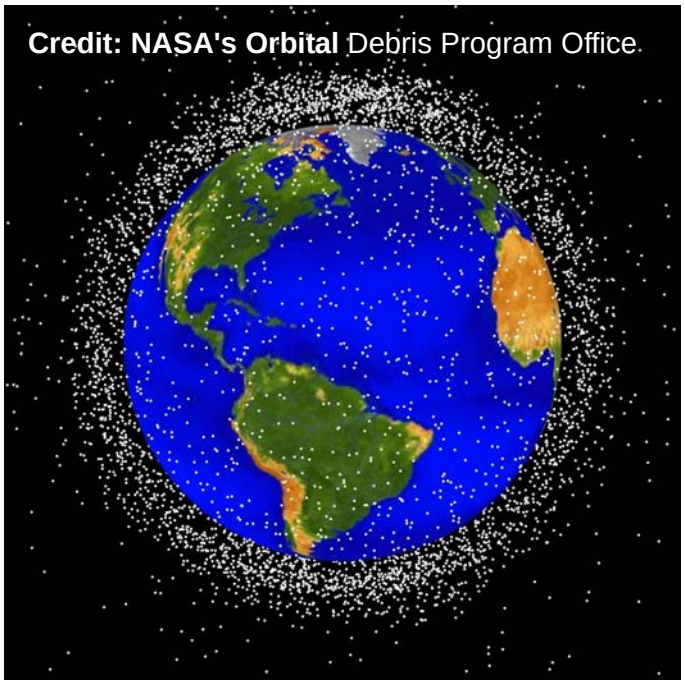
In 2006, the right-hand payload bay door radiator of the space shuttle Atlantis was hit by space debris. The object blasted its way through the metal skin and aluminum honeycomb material inside before exiting the other side. The resulting hole missed the Freon coolant lines inside the panel and did not endanger the crew. (The radiators were only deployed once the shuttle is in space and were stored in the cargo bay during reentry.) However, the impact illustrates the danger presented by space debris to spacecraft and their human occupants.

The Hubble Space Telescope's Wide Field Planetary Camera 2 was returned to Earth as part of the telescope's servicing mission in 2009 (STS-125). Attached to the camera was a large radiator (2.2 m by 0.8 m). The radiator had been in space since the camera was installed in 1993, and its large flat surface provided an excellent measure for determining impact rates for orbital debris at the telescope's altitude (between 560 and 620 km). Initial analysis of the radiator found a total of 685 micrometeoroid and orbital debris impact features (larger than about 0.3 mm).

It is estimated that tens of millions of man-made objects also orbit the Earth, the vast majority smaller than 1 centimeter in size. The objects come from derelict spacecraft, exploding rocket boosters, discarded motors, deterioration of man-made structures including thermal blankets and solar panels, as well as from accidental and deliberate collisions. The objects orbit the Earth in many different directions, altitudes, and velocities, traveling up to 30,000 miles an hour or 20 times faster than a rifle bullet. At these speeds, it doesn't take a very large object to inflict considerable damage to another object, including the International Space Station (ISS). The space shuttle windows were hit by small pieces of debris 32 times during an average mission. Micrometeorites were involved in approximately one-third of the collisions. The grains of sand are generally less dense than man-made debris, and therefore, relatively harmless. The remaining two-thirds do have some penetrating power and are primarily bits of aluminum, followed by paint, steel, and copper.



Pit in Space Shuttle window from impact with paint chip



Orbital Debris in Low-Earth Orbit.

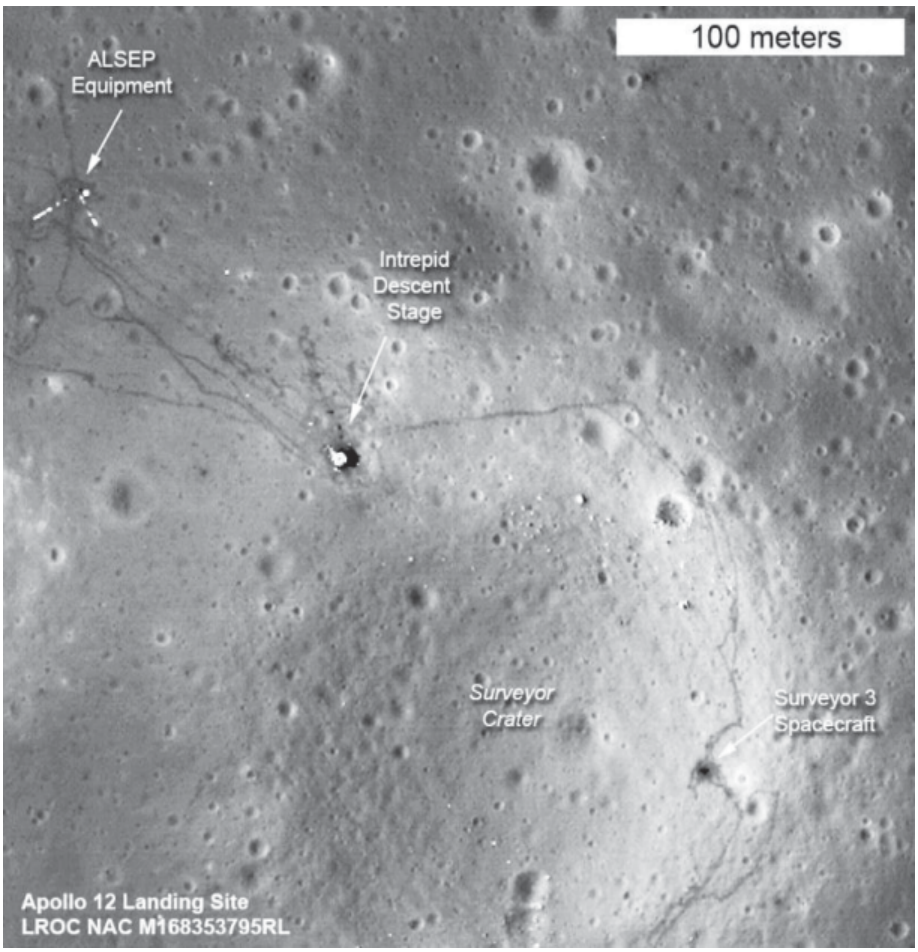
NASA currently tracks almost 19,000 objects—most are larger than 10 centimeters (4 inches). This is double the number of objects tracked ten years ago. (There may be 500,000 debris fragments greater than one centimeter in size and over a 100 million fragments smaller than a centimeter). While the United States and Russia are the largest contributors to the swarm of man-made objects, newer space faring nations, most notably, China, have added to the problem (particularly after China's intentional destruction of its Fengyun 1C weather satellite—the single largest debris producing event). While debris in low-Earth orbit will eventually fall back to the surface, objects higher than 800 kilometers (480 miles) can continue to circle the planet for decades and even centuries.

Until a solution can be found to cleaning up the debris (that is both technically and economically feasible), NASA has developed guidelines it hopes other nations will adopt to minimize the creation of even more debris. In the meantime, surveillance of the existing debris (only practical for the larger objects) will allow spacecraft that can maneuver to avoid future collisions, and more importantly, the loss of life. For additional information, NASA publishes the "Orbital Debris Quarterly News," complete with a "satellite box score." The newsletter (past and present) is available at *http:/rbitaldebris.jsc.nasa.gov/newsletter/newsletter.html*.

November History: Apollo 12

The second manned mission to the lunar surface was launched on November 14, 1969. The mission was almost lost before it started. The Saturn V rocket booster was hit by lightning as it rose from the launch pad. Fortunately, a young flight controller in mission control (John Aaron) remembered seeing the same dizzying display of warning lights and alarms in a practice run and was able to provide the crew directions on re-establishing power and control to the spacecraft.

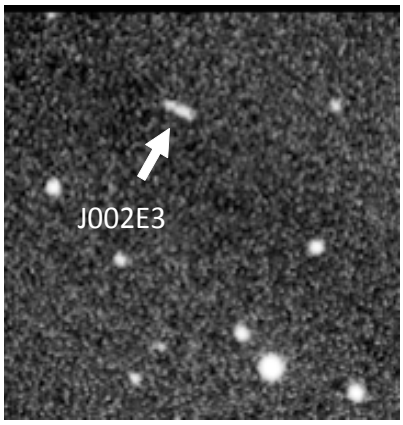
After leaving Earth orbit, the command module extracts the lunar excursion module from the third stage. The trajectory (or path) of the third stage is then modified, so as not to interfere with the lunar landing (either by placing it into orbit around the Sun or deliberately crashing it into the Moon). In what would become of interest 33 years later, the engine on the third stage burned 300 seconds too long, sending the rocket booster into a semi-stable orbit around the Earth. Two years later, it finally entered into an orbit around the Sun (by passing through a region of space controlled by the Earth and Sun).



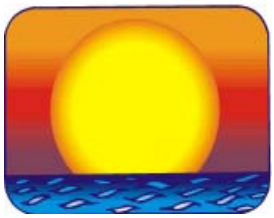
The Ocean of Storms was the designated landing site for Apollo 12, southeast of the large crater Lansberg. Mission Commander Pete Conrad made a pinpoint landing 535 feet from the Surveyor 3 spacecraft which had landed two years earlier. The diminutive Conrad joked as he stepped out onto the lunar surface for the first time: "Whoopee! Man, that may have been one small one for Neil, but that's a long one for me."

In 2002, amateur astronomer Bill Yeung discovered a new

object orbiting the Earth. Designated J002E3, the object was later determined to be artificial (from the analysis of reflected sunlight). After considerable study, it was concluded that J002E3 was most likely the third stage of Apollo 12. The object made six elongated orbits of the Earth before disappearing, presumably returning to its previous orbit around the Sun.



J002E3 was imaged from the McCarthy Observatory during three of its close approaches to Earth. Although the images are just snapshots, the tumbling motion of the booster is clearly seen as the sunlight alternately reflects off the white painted sides of the rocket and then the darkened ends.



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
November 1st (EDT)	07:26	17:48
November 15th (EST)	06:43	16:34
November 30th	07:00	16:25

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

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

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

Astronomical and Historical Events

1st History: launch of the Wind spacecraft, designed to monitor the solar wind (1994)
1st History: opening of the Arecibo Observatory (radio telescope) in Arecibo, Puerto Rico (1963)
2nd Centaur Object 49036 Pelion at Opposition (20.002 AU)
2nd History: flyby of Asteroid 5535 Annefrank by the Stardust spacecraft (2002)
2nd History: first light at the 100-inch telescope on Mount Wilson (1917)
3nd Amor Asteroid 2016 VH2 near-Earth flyby (0.064 AU)
3nd Taurids Meteor Shower peak (associated with the comet Encke)
3nd History: launch of Mariner 10 to Venus and Mercury; first mission to use the gravitational pull of one planet (Venus) to reach another (Mercury) (1973)
3nd History: launch of Sputnik 2 and a dog named Laika (1957)
4nd End of Daylight Savings Time - set clocks back one hour at 2 a.m.
4nd Aten Asteroid 2002 VE68 near-Earth flyby (0.038 AU)
4nd Plutino 47171 (1999 TC36) at Opposition (29.628 AU)
4th Kuiper Belt Object 472271 (2014 UM33) at Opposition (42.710 AU)
4th History: Deep Impact's closest approach to the nucleus of Comet 103P/Hartley 2 (2010)
4th History: launch of the Soviet Venus lander Venera 14 (1981)
5th Parker Solar Probe's first close encounter with the Sun's corona (0.17 AU)
5th Kuiper Belt Object 120348 (2004 TY364) at Opposition (38.050 AU)
5th History: launch of India's Mars Orbiter Mission (MOM) from the Satish Dhawan Space Centre (2013)
5th History: Chinese spacecraft Chang'e 1 enters orbit around Moon (2007)
6th Mercury at its Greatest Eastern Elongation-apparent separation from the Sun in the evening sky (23°)
6th Atira Asteroid 418265 (2008 EA32) closest approach to Earth (1.293 AU)
6th Plutino 144897 (2004 UX10) at Opposition (38.310 AU)
6th Kuiper Belt Object 2014 UZ224 at Opposition (89.746 AU)
6th History: launch of Lunar Orbiter 2, Apollo landing site survey mission (1966)
7th New Moon
7th Aten Asteroid 2010 VQ near-Earth flyby (0.040 AU)
7th Apollo Asteroid 2015 NU2 near-Earth flyby (0.068 AU)
7th Kuiper Belt Object 55637 (2002 UX25) at Opposition (39.490 AU)
7th History: launch of Mars Global Surveyor (1996)
7th History: launch of Surveyor 6 moon lander (landed two days later). On November 17th, the lander's small vernier engines were fired for 2½ seconds, lifting the lander off the lunar surface 10 to 12 feet and almost 8 feet sideways. This lunar "hop" was the first powered takeoff from the lunar surface. It also provided NASA a view of the original landing site and a baseline for acquiring stereoscopic images of its surroundings. (1967)
7th History: French astronomer Pierre Gassendi first to observe a transit of the planet Mercury across the Sun's disk (1631)
8th Aten Asteroid 2010 VB near-Earth flyby (0.082 AU)
8th Kuiper Belt Object 84522 (2002 TC302) at Opposition (43.417 AU)
8th History: launch of the ill-fated Phobos-Grunt spacecraft from the Baikonur Cosmodrome in Kazakhstan. Destined for the Martian moon Phobos, the spacecraft never left Earth orbit and eventually re-entered the atmosphere. (2011)
8th History: meteorite hits a house in Wethersfield, Connecticut (1982)
8th History: launch of Pioneer 9 into solar orbit (1968)
8th History: launch of Little Joe rocket, qualifying flight for the Mercury spacecraft (1960)
8th History: Edmund Halley born, English astronomer who calculated the orbit and predicted the return of the comet now called Comet Halley (1656)
9th History: launch of OFO-1 (Orbiting Frog Otolith) - two bullfrogs launched in an experiment to monitor the adaptability of the inner ear to sustained weightlessness (1970)

Astronomical and Historical Events (continued)

9th History: launch of the Venus Express spacecraft; ESA Venus orbiter (2005)
9th History: launch of the first Saturn V rocket, Apollo 4 (1967)
10th Second Saturday Stars - Open House at the McCarthy Observatory (7:00 pm)
10th History: launch of Luna 17, Soviet Moon rover mission (1970)
10th History: launch of USSR spacecraft Zond 6; Moon orbit and return (1968)
10th History: Waseda Meteorite Fall; hits house in Japan (1823)
11th History: launch of Gemini 12 with astronauts James Lovell and Edwin Aldrin (1966)
11th History: Tycho Brahe discovers a new star in the constellation Cassiopeia shining as bright as Jupiter; later determined to be a supernova - SN1572 (1572)
12th Moon occults Pluto
12th Apollo Asteroid 2018 QN1 near-Earth flyby (0.055 AU)
12th Aten Asteroid 2011 WA near-Earth flyby (0.067 AU)
12th Centaur Object 2015 KJ153 at Opposition (6.337 AU)
12th History: launch of STS-2, second flight of the Space Shuttle Columbia (1981)
12th History: flyby of Saturn by the Voyager 1 spacecraft (1980)
12th History: Seth Nicholson born, American astronomer who discovered four of Jupiter's moons, a Trojan asteroid, and computed orbits of several comets and of Pluto (1891)
13th Apollo Asteroid 2015 VM105 near-Earth flyby (0.080 AU)
13th Apollo Asteroid 2016 WC near-Earth flyby (0.088 AU)
13th History: launch of HEAO-2, the second of NASA's three High Energy Astrophysical Observatories; renamed Einstein after launch, it was the first fully imaging X-ray space telescope (1978)
14th Moon at apogee (furthest distance from Earth)
14th Apollo Asteroid 2018 UQ1 near-Earth flyby (0.024 AU)
14th History: dedication of the New Milford Solar System Scale Model (2009)
14th History: Mariner 9 arrives at Mars; first spacecraft to orbit another planet (1971)
14th History: launch of Apollo 12, with astronauts Pete Conrad, Richard Gordon and Alan Bean to the moon's Ocean of Storms and near the robotic explorer Surveyor 3 (1969)
14th History: discovery of the Great Comet of 1680 or Kirch's Comet by Gottfried Kirch (1680)
15th First Quarter Moon
15th Atira Asteroid 481817 (2008 UL90) closest approach to Earth (1.237 AU)
15th Scheduled launch of a Cygnus cargo freighter to the International Space Station from Wallops Island, Virginia aboard an Antares rocket
15th History: William Herschel born, German-English astronomer, credited with the discovery of Uranus, two of its moons, two of Saturn's moons and catalogued the heavens (1738)
15th History: ESA's spacecraft SMART-1 enters lunar orbit; first ESA Small Mission for Advanced Research in Technology; travelled to the Moon using solar-electric propulsion and carrying a battery of miniaturized instruments (2004)
15th History: the only orbital launch of the Russian space shuttle Buran; the unmanned shuttle orbited the Earth twice before landing (1988)
15th History: launch of Intasat, Spain's first satellite (1974)
16th Kuiper Belt Object 2012 VP113 at Opposition (82.801 AU)
16th History: launch of the third (and last) Skylab crew with astronauts Gerald Carr, William Pogue and Edward Gibson (1973)
16th History: launch of Venera 3, Soviet Venus lander (1965)
17th Leonids Meteor Shower peak (associated with the comet Tempel-Tuttle)
17th History: Surveyor 6 performs a "hop" maneuver, moving approximately 8 feet (2.5 meters) away from its original landing area - enabling scientists to validate surface properties (1967)
17th History: launch of Soyuz 20, a 90 day, long duration mission that carried a biological payload (tortoises) that docked with the Salyut 4 space station. The tortoises returned to Earth in good health (1975)

Astronomical and Historical Events (continued)

17th History: Soviet lunar lander Luna 17 deploys first rover - Lunokhod 1 (built by the Kharkov state bicycle plant); operated for 11 months, photographing and mapping the lunar surface and analyzing the regolith (1970)
18th Apollo Asteroid 25143 Itokawa closest approach to Earth (0.706 AU)
18th Plutino 455502 (2003 UZ413) at Opposition (43.043 AU)
18th History: launch of the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft (Mars Orbiter) from the Cape Canaveral Air Force Station (2013)
18th History: launch of the COBE spacecraft; observed diffuse cosmic background radiation (1989)
19th Comet 9P/Tempel at Opposition (3.654 AU)
19th Apollo Asteroid 518735 (2009 JL1) near-Earth flyby (0.083 AU)
19th Apollo Asteroid 3200 Phaethon closest approach to Earth (1.428 AU)
19th Centaur Object 37117 Narcissus at Opposition (2.112 AU)
19th Kuiper Belt Object 2010 VK201 at Opposition (47.086 AU)
20th Kuiper Belt Object 90377 Sedna at Opposition (83.975 AU)
20th History: the Japan Aerospace Exploration Agency's Hayabusa spacecraft lands on Asteroid 25143 Itokawa for sample collection (2005)
20th History: launch of the Swift spacecraft; first-of-its-kind multi-wavelength observatory dedicated to the study of gamma-ray bursts (2004)
21st Amor Asteroid 2013 PA7 near-Earth flyby (0.091 AU)
21st Plutino 84719 (2002 VR128) at Opposition (38.834 AU)
22st Apollo Asteroid 410088 (2007 EJ) near-Earth flyby (0.062 AU)
22rd Atira Asteroid 2006 WE4 closest approach to Earth (1.493 AU)
23rd Full Moon (Beaver Moon)
23rd Centaur Object 54598 Bienor at Opposition (13.867 AU)
23rd History: launch of the European Space Agency's first satellite, Meteosat 1 (1977)
23rd History: launch of Tiros II weather satellite (1960)
24th Amor Asteroid 2011 AA37 near-Earth flyby (0.099 AU)
25th Aten Asteroid 2009 WB105 near-Earth flyby (0.039 AU)
25th History: Albert Einstein publishes his General Theory of Relativity (1915)
25th History: William Dawes discovers Saturn's C Ring (1850)
26th Moon at perigee (closest approach to Earth)
26th Landing of NASA's InSight lander on Mars western Elysium Planitia
26th Mars Cube One 1 & 2, Mars flyby (launched with InSight to monitor landing)
26th History: launch of the Mars Science Laboratory (MSL) aboard an Atlas 5 rocket from the Cape Canaveral Air Force Station (2011)
26th History: discovery of Mars meteorites SAU 005 and SAU 008 (1999)
26th History: launch of France's first satellite, Asterix 1 (1965)
26th History: launch of Explorer 18; studied charged particles and magnetic fields in and around the Earth - Moon (1963)
26th History: discovery of the Orion Nebula by French astronomer Nicolas-Claude Fabri de Peiresc (1610)
27th Apollo Asteroid 2008 WD14 near-Earth flyby (0.019 AU)
27th History: Soviet spacecraft Mars 2 arrives at Mars; lander crashes, becoming first human artifact to impact the surface of Mars (1971)
28th Apollo Asteroid 2001 WO15 near-Earth flyby (0.035 AU)
28th Aten Asteroid 2013 BT18 near-Earth flyby (0.072 AU)
28th History: launch of Algeria's first satellite, Alsat 1 (2002)
28th History: discovery of first Pulsar by Jocelyn Bell and Antony Hewish (1967)
28th History: launch of Mariner 4; first spacecraft to obtain and transmit close range images of Mars (1964)

Astronomical and Historical Events (continued)

29th Last Quarter Moon
29th Atira Asteroid 164294 (2004 XZ130) closest approach to Earth (1.047 AU)
29th Kuiper Belt Object 386723 (2009 YE7) at Opposition (49.817 AU)
29th History: discovery of Y000593 Mars meteorite in Antarctica (2000)
29th History: launch of Australia's first satellite, Wresat 1 (1967)
29th History: launch of Mercury 5 with Enos the chimpanzee (1961)

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

International Space Station/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.

Solar Activity

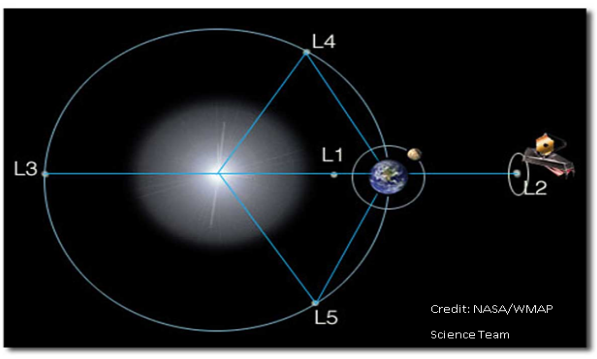
For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com.

NASA's Global Climate Change

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

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).



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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 Graphic

October 20th is the International Observe the Moon Night (InOMN).

The event was first inspired by public outreach events held in August 2009 by the Lunar Reconnaissance Orbiter (LRO) and Lunar CRater Observation and Sensing Satellite (LCROSS) educational teams at the Goddard Space Flight Center in Greenbelt, Maryland and at the Ames Research Center in Moffett Field, California, respectively. In 2010, the Lunar and Planetary Institute and Marshall Space Flight Center joined Goddard and Ames in a world-wide event to raise public awareness of lunar science and exploration. Information on InOMN events is available on their website *http://observethemoonnight.org*/.

The image was taken from High Rock Observatory in in Lynn Massachusetts by JJMO member Bill Cloutier. It shows the fading shadow of a waxing Gibbous Moon as it turns toward the Sun to become a Full Moon.

The phases of the Moon appear reversed to observers in the southern hemisphere, where the lunar terminator - or border between bright and dark - moves in the opposite direction, from west to east. Along the Equator the terminator appears horizontal to observers.

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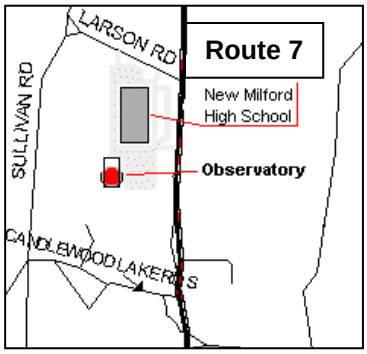

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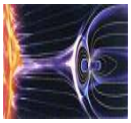
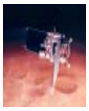
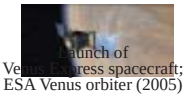
November 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1  Launch of Wind spacecraft to study solar wind (1994)	**2** End of Daylight Savings Time   First light of Mt. Wilson 100-inch telescope - (1917) Harlow Shapley born, American astronomer, measured distances within our galaxy (1885) 	**3** Taurids meteor showers peak   Launch of Mariner 10 to Venus and Mercury (1973) Launch of Sputnik 2, with dog Laika (1957) 
4  Chinese spacecraft Chang'e 1 enters orbit around Moon (2007)  Deep Impact closest approach to the nucleus of Comet 103/P Hartley 2 (2010)	**5**  Fred Lawrence Whipple born, American astronomer; first to theorize of comets as "dirty snowballs" (1906)	**6**  Lunar Orbiter 2 launch (1966) Charles Owen Hobaugh, NASA astronaught born (1961) 	**7**  Launch of Mars Global Surveyor (1996) Launch of Surveyor 6 Moon Lander, dry-run for later manned mission (1967) 	**8**  Launch of Little Joe rocket (1960) Meteorite hits house in Wethersfield CT (1982)   Edmund Halley born (1656)	**9**  Launch of 1st Saturn V rocket - Apollo 4 (1967)  Launch of Venus Express spacecraft; ESA Venus orbiter (2005)	**10**  Launch of Soviet spacecraft Zond 6 to Moon (1968) Launch of Luna 17, Soviet Moon Rover mission (1970)   Waseda meteor hits house in Japan (1823)  2nd Saturday Stars Open House McCarthy Observatory
11  Tycho Brahe discovers supernova SN1572 (bright as Jupiter) (1572) Launch of Gemini 12, with astronauts Lovell and Aldrin (1966) 	**12**  Seth Nicholson born, American astronomer (1891) Space Shuttle Columbia safe re-launch, with commander Joe Engle and pilot Richard Truly (1981) 	**13**  Launch of HEAO-2 (Einstein), 1st fully-imaging x-ray telescope in space - 1978 Dawn spacecraft enters Asteroid Belt on way to Vesta and Ceres (2009) 	Moon at apogee (farthest from Earth) **14**   Launch of Apollo 12 - Gordon, Bean, 1969 Mariner 9 arrives at Mars, 1st spacecraft to orbit another planet, 1971   Dedication of the New Milford solar system scale model (2009)	**15** Astronomer William Herschel born (1738)   ESA Smart-1 enters lunar orbit, using solar-electric propulsion 2004 Only orbital launch of Russian Buran space shuttle in unmanned mission (1988) 	**16**  Launch of Venera 3, Soviet Venus lander (1965)  Launch of 3rd and last Skylab crew - Carr, Pogue, Gibson (1973)	**17**  Soviet lunar lander, Luna 17 with 1st rover, Lunakhod 1 (1970) Leonids meteor shower peak 
18 Leonids Meteor Storm (2001) Alan Shepard born, 1st American in space and 5th to walk on Moon - 1923 Launch of the COBE spacecraft; observed diffuse cosmic background radiation (1989)	**19** Apollo 12 astronauts Charles Conrad and Alan Bean made man's second landing on the moon (1969)	**20** Launch of the Swift spacecraft, multi-wavelength observatory to study gamma wave bursts (2004)	**21** India's space program begins with the launch of a Nike-Apache sounding rocket from coconut groves in Thumba, a small fishing village in Kerala state (1963)	**22** Dr. Guion Stewart "Guy" Bluford, Jr. born - an engineer, NASA astronaut, and the first African American in space (1942)	**23** Launch of European Space Agency's 1st satellite, Meteosat (1977) launch of Tiros II weather satellite (1960) 	**24** Space-walking astronauts from shuttle Columbia catch a 1 1/2 -ton satellite, and the cockpit crew used the shuttle's robot arm to return it to the cargo bay (1997)
25 Radio signals exchanged between Viking 1 Mars Lander and Earth are slowed by sun's gravity, confirming Einstein's general theory of relativity (1976)	Moon at Perigee (closest to Earth) **26** Launch of France's first satellite, Asterix 1 (1965) Launch of Explorer 18; studied charged particles and magnetic fields in and around the Earth - Moon (1963) Scheduled touchdown of InSight lander on Mars western Elysium Planitia	**27** Soviet spacecraft Mars 2, first human artifact to impact Martian surface (1971)	**28** Launch of Algeria's 1st satellite, Alsat 1 (2002) Launch of Mariner 4, first spacecraft to send close range images of Mars (1964) Comet C/2012 S1 (ISON) Perihelion (0.012 AU)	**29** Launch of Australia's 1st satellite, Wresat 1 1967 Launch of Mercury 5, with Enos the chimp 1961	**30** Sylicauga meteorite fall strikes Alabama woman (1954)	

Phases of the Moon