Galactic Observer

John J. McCarthy Observatory

Volume 11, No. 6 June 2018

An infrared image of the Lagoon Nebula taken for the celebration of the 28th anniversary of the Hubble Space Telescope, conducted by its cofounders, NASA and the European Space Agency. Infrared imaging penetrates the dust and gas of the nebula to reveal the the fine details of the stellar background.

Turn to page 11 for a visible light image of the nebula revealing all the color and grandeur of this wonder of the universe.

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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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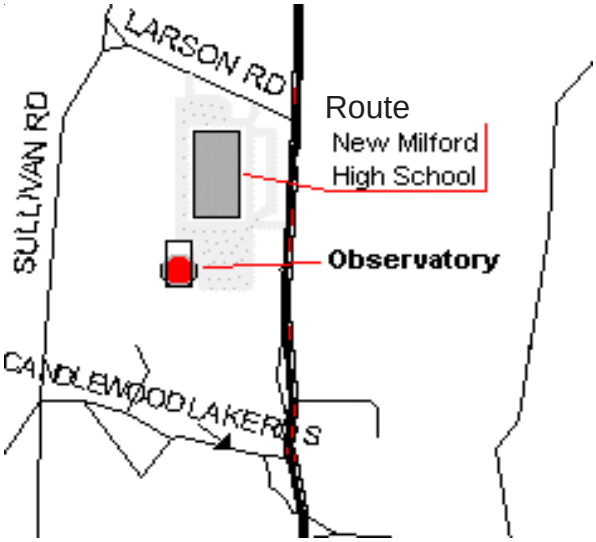

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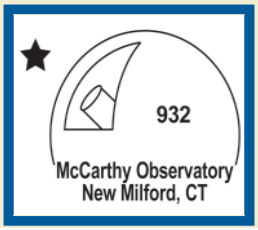
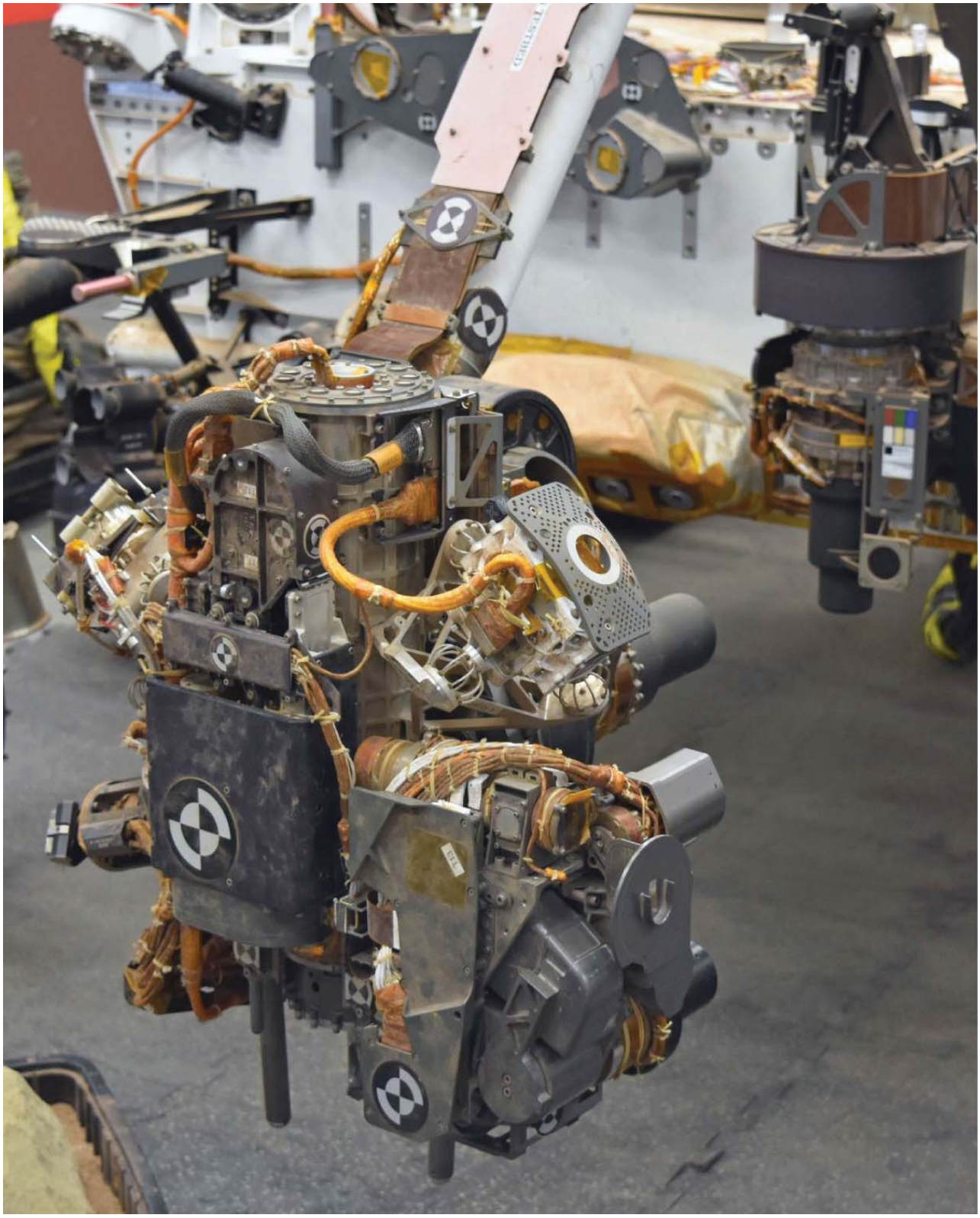


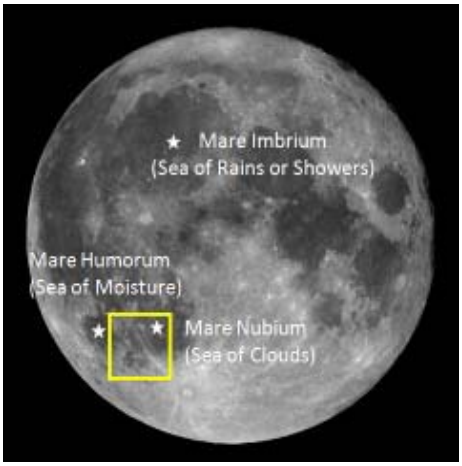
June Astronomy Calendar
and Space Exploration Almanac



Mars Science Laboratory (Earth-bound twin) Turret or "Hand," equipped with an Alpha Particle X-ray Spectrometer, imager, and sample collection devices
Photo Credit: Bill Cloutier

Out the Window on Your Left"

IT'S BEEN MORE than 45 years since we left the last foot print 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).



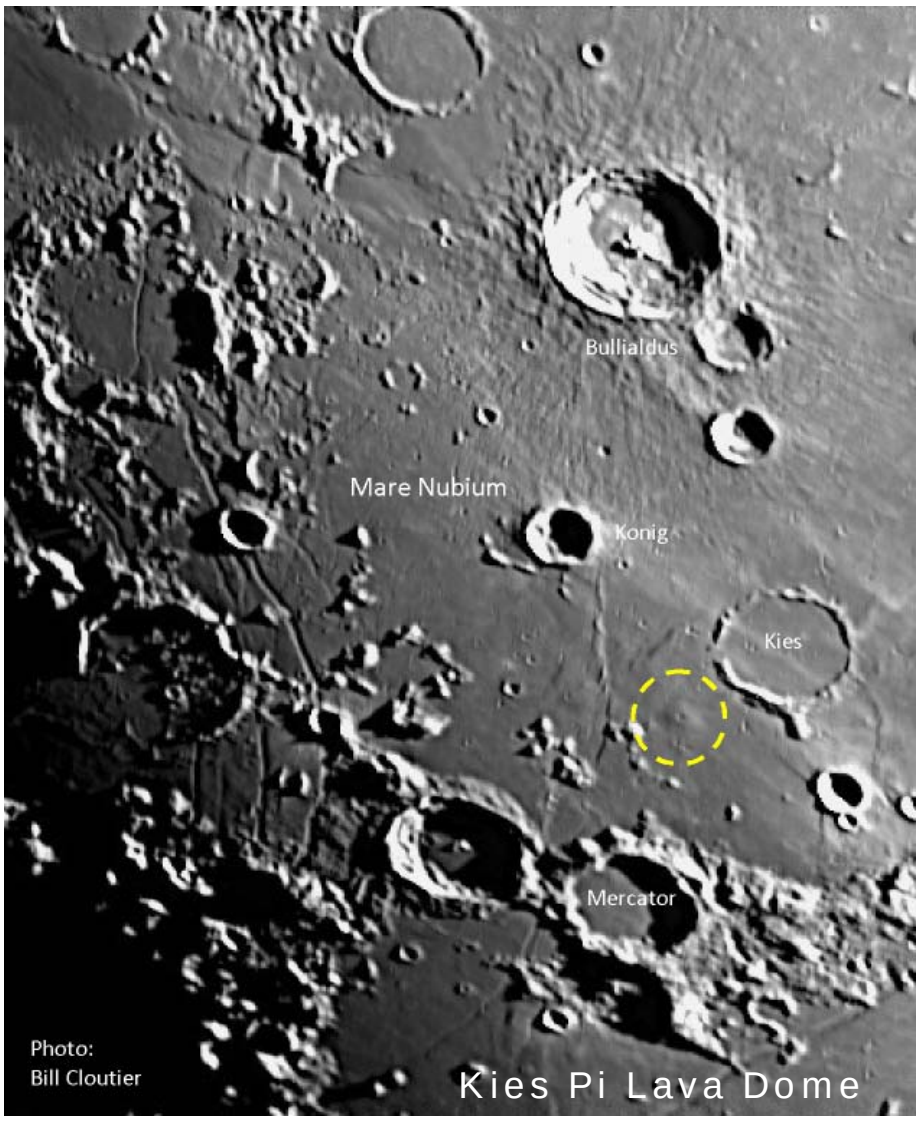
Lunar seas are actually expansive low-lying plains formed by ancient lava flows

The Sun is rising on Mare Nubium (Sea of Clouds) in this month's image. It was an area first targeted by NASA's Lunar Reconnaissance Orbiter's camera (LROC) when the spacecraft arrived on orbit in 2009. The impact basin in which the mare resides has a diameter of approximately 430 miles (690 km) and is older than the nearby Imbrium and Humorum basins.

Impacts, such as the one that created Bullialdus crater (38 miles or 61 km in diameter), have excavated rock from beneath the relatively thin mare (estimated at less than 1,600 feet or 500 meters thick). Starting at Bullialdus, lunar observers can locate the flooded crater Kies (28 miles or 46 km in diameter) to the south, along the basin's edge. In the mare east of Kies crater is the lava dome Kies (Pi). The dome is approximately 6 miles wide (10 km), with gently sloping sides and a distinct caldera, similar in appearance to shield volcanoes on Earth.

Lunar domes likely formed during the later stages of lunar volca-

East - West profile of Kies Pi Dome. Credit: LROC Quickmap



Southwest shore of Mare Nubium (Sea of Clouds)

nism. They range in size from 5 to 8 miles (8 to 12 km) in diameter and 600 to 700 feet high (200 meters). Shield volcanoes form when lava, with a low viscosity that allows it to flow easily, begins to crystalize and cool, building up over time around vents and fissures. Accumulating lava flows form a broad mound until the source of magma is exhausted and/or retreats. Collapse of magma lakes or pools create pits near the summit.

InSight

NASA's Discovery Program mission InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) lifted off on a foggy morning from the Vandenberg Air Force Base in California aboard a United Launch Alliance (ULA) Atlas V rocket. The launch, on May 5th, was the agency's first interplanetary mission from the west coast. Approximately 90 minutes after liftoff, the spacecraft separated from the Centaur upper stage, commencing its six month, 300 million mile interplanetary cruise. InSight is currently scheduled to land on Mars' Elysium Planitia, a relatively smooth plain in Mars' northern hemisphere, and named after a mythical paradise of the afterlife, on November 26th.

The 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. A 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. A 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 its 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 expected to contribute to our understanding of the formation of other rocky and terrestrial planets (as well as exoplanets).

MarCO

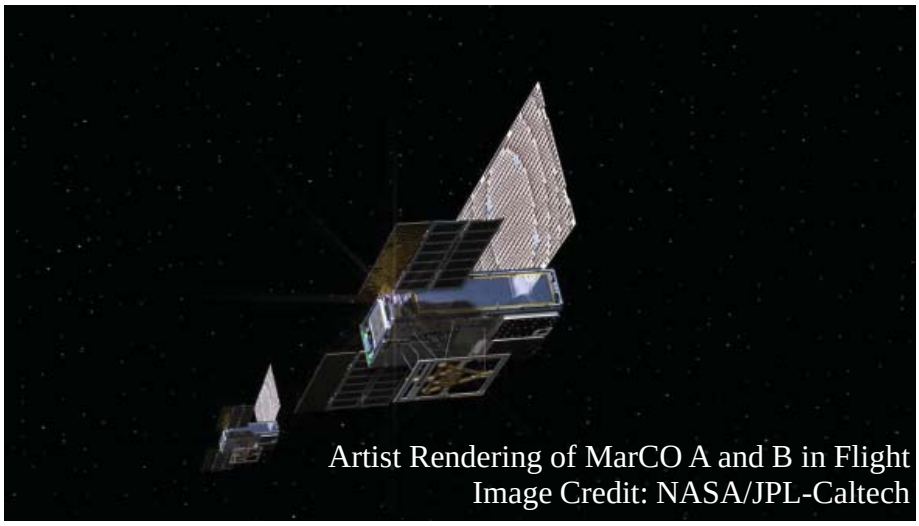
The Atlas V that propelled InSight on its way to Mars is a two stage rocket. The first stage, powered by kerosene fuel (type RP-1) and liquid oxygen, accelerates the rocket to 10,000 miles per hour. The second stage, the Centaur, carries the payload into low-Earth orbit using a restartable engine powered by liquid hydrogen and liquid oxygen. Once an Earth orbit has been achieved, the engine is restarted, sending the payload towards its destination.

Stowed inside the Centaur's bulkhead were two (for redundancy) experimental mini-spacecraft called Mars Cube One, or MarCO (A and B). Once InSight separated from the upper stage, the two CubeSats were released, on separate trajectories towards the Red Planet. It is the first time CubeSats have operated beyond Earth orbit. If they are successful in reaching Mars, MarCO will arrive as InSight prepares to enter the Martian atmosphere. The briefcase-size-spacecrafts, equipped with an Ultra-High Frequency antenna to receive transmissions from InSight, will be able to relay data directly back to NASA's Deep Space Network on Earth from a distance of 97.5

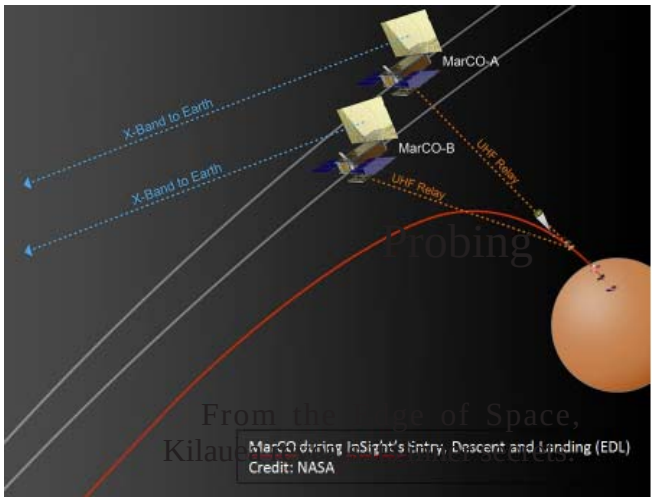
million miles (157 million kilometers). There will be an almost 9 minute delay in the receipt of data due to the distance (8.7 light minutes).

MarCO is a demonstration project and therefore, not critical to InSight's mission success (the Mars Reconnaissance Orbiter will be the primary data relay for the landing). However, if successful, CubeSats may prove to be a valuable resource for relaying data, particularly where there are no other assets available at the destination.

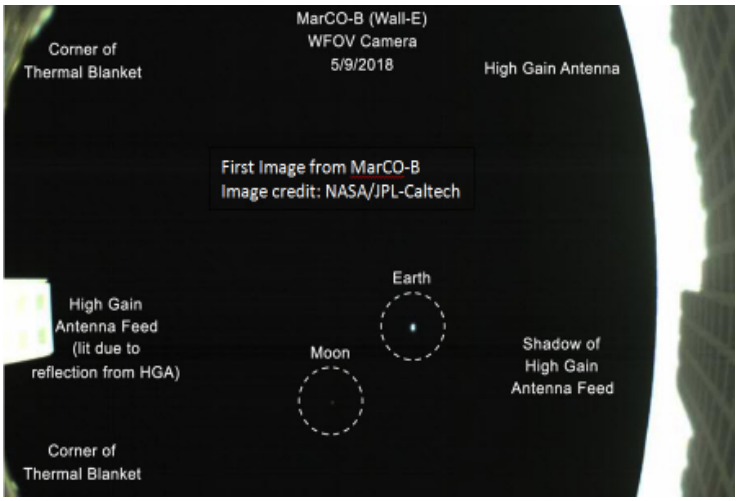
Shortly after separation, MarCO deployed its solar panels. NASA has received radio signals from the CubeSats and engineers are going through a system checkout before the miniature spacecraft enter their long cruise phase. The spacecraft use R236FA gas (commonly used in fire extinguishers) as propellant to adjust their trajectory. The CubeSats are also equipped with a wide-field camera, used to confirm the deployment of the high-gain antenna, and a narrow-field camera.



Artist Rendering of MarCO A and B in Flight
Image Credit: NASA/JPL-Caltech



MarCO during InSight's Entry, Descent and Landing (EDL)
Credit: NASA



Saturn at Opposition

The Earth will come between Saturn and the Sun on June 27th, an arrangement known as "Opposition." On that day, Saturn will rise in the evening sky opposite the setting Sun and reach its highest point in the sky at midnight. At closest approach, Saturn will be approximately 841.1 million miles (1.35 billion km) from Earth, slightly further away than in 2017. The difference in appearance (diameter) won't be noticeable. Saturn can be found in the constellation Sagittarius.

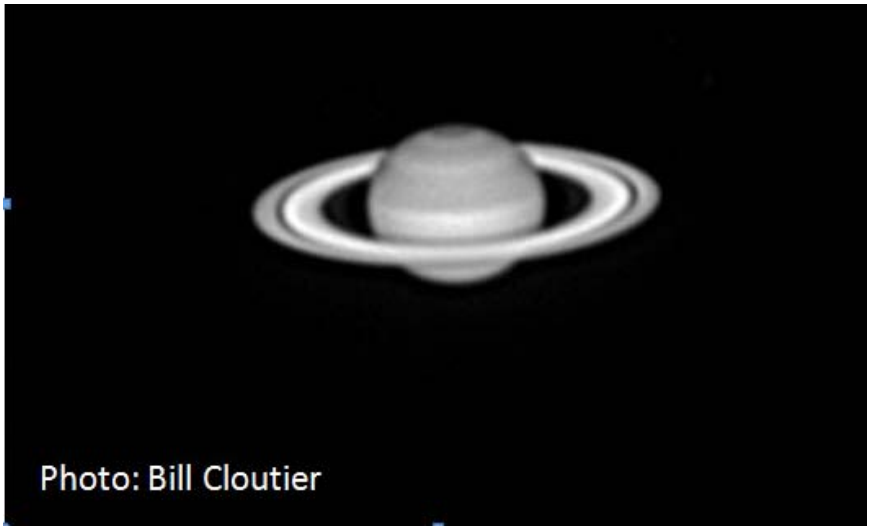


Photo: Bill Cloutier

Saturn will be relatively bright this year, with an apparent magnitude of +0.0 (as compared to Jupiter at magnitude -2.3 in June). Saturn's axial tilt is almost 27° (as compared to Earth's 23.5° or Jupiter's 3°). The axial tilt produces seasons which last more than 7 years, since it takes Saturn almost 29½ years to complete an orbit around the Sun. It was summer in the southern hemisphere when the Cassini spacecraft arrived in 2004, with the planet's north pole in perpetual darkness. Saturn's Vernal equinox occurred in August 2009 with both hemispheres experiencing equal amounts of sunlight (at equinox, the rings appear almost edge on). Since that time, our view of the rings has improved. With the northern summer solstice in May 2017, the rings are wide open with the planet's north pole sunlit and tipped towards Earth. This year the ring tilt is one of the best at 26° (slightly less than in 2017).

Mars Trace Gas Orbiter

The European Space Agency's (ESA) Trace Gas Orbiter (TGO) arrived at Mars in October 2016. The initial highly elliptical orbit has been gradually modified to a more circular orbit over the past two years by a process called "aerobraking." In aerobraking, the spacecraft dips into the planet's upper atmosphere. The atmospheric drag slows the spacecraft, lowering its orbit. The precision flying, using the Martian atmosphere to shape the spacecraft's orbit, has been repeated over 950 times. With a final adjustment by TGO's thrusters, the spacecraft is now in a 250 mile (400 km) orbit around the Red Planet and has commenced science operations.

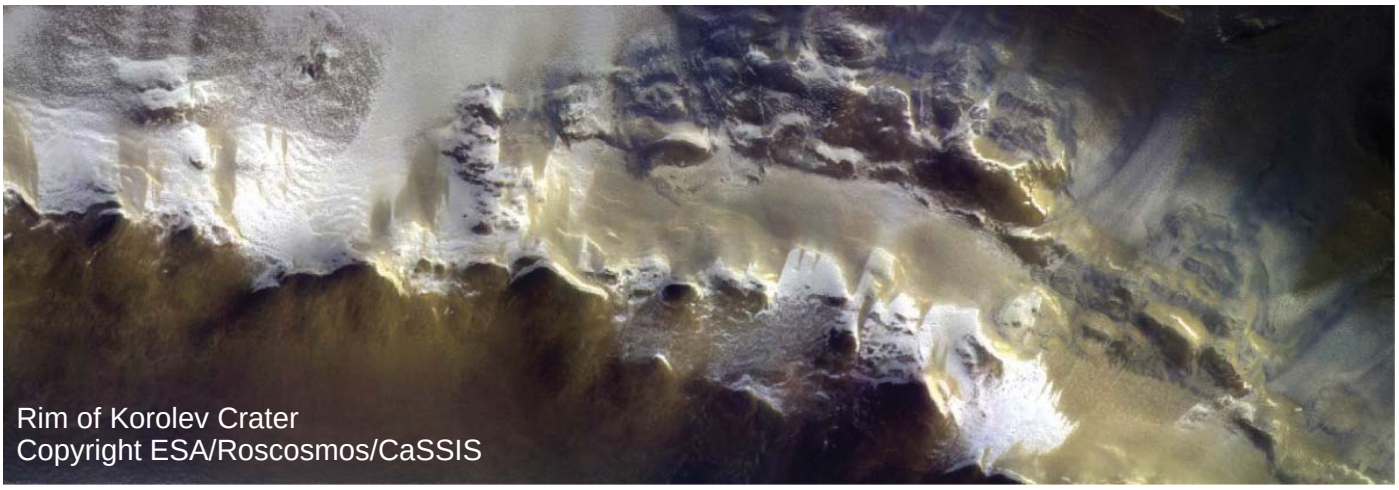
TGO's primary mission is to analyze the thin Martian atmosphere for trace gases (less than 1% of the volume), such as methane, and identify possible source(s) on the planet's surface, including potential geologic or biologic activity, that can be targeted for future exploration. In 2020, ESA and Roscosmos (Russian space agency) are scheduled to send a lander/rover to Mars to a landing area selected, in part, by the work being done by TGO. The TGO spacecraft will also act as a communications relay for the pair, as well as for NASA missions.

TGO is equipped with four instruments, which includes the Colour and Stereo Surface Imaging System, CaSSIS. The camera will be used, in conjunction with the spacecraft's spectrometers (for chemical analysis) and a neutron detector (to measure hydrogen/water abundance) to correlate surface features with trace gas production. CaSSIS returned is first images of Mars in mid-April, which included a striking view of the rim of Korolev Crater. The crater is l ocated in the northern hemisphere, at a latitude of 73.3°N. Patches of ice can be seen in the photo along the rim segment.

NASA's Mars Odyssey had previously detected a thick layer of ice-rich material within the 50 mile diameter (80 km) crater and seasonal variations due to the crater's proximity to the planet's polar ice cap, for example, from the condensation of carbon dioxide during the winter and water vapor during the summer season.

Gaia

The European Space Agency (ESA) launched its Gaia satellite in December 2013 with mission objectives that included the precise positional measurement of the stars in our galaxy, spectral composition, and stellar motion. Gaia is building on the accomplishments of the Hipparcos

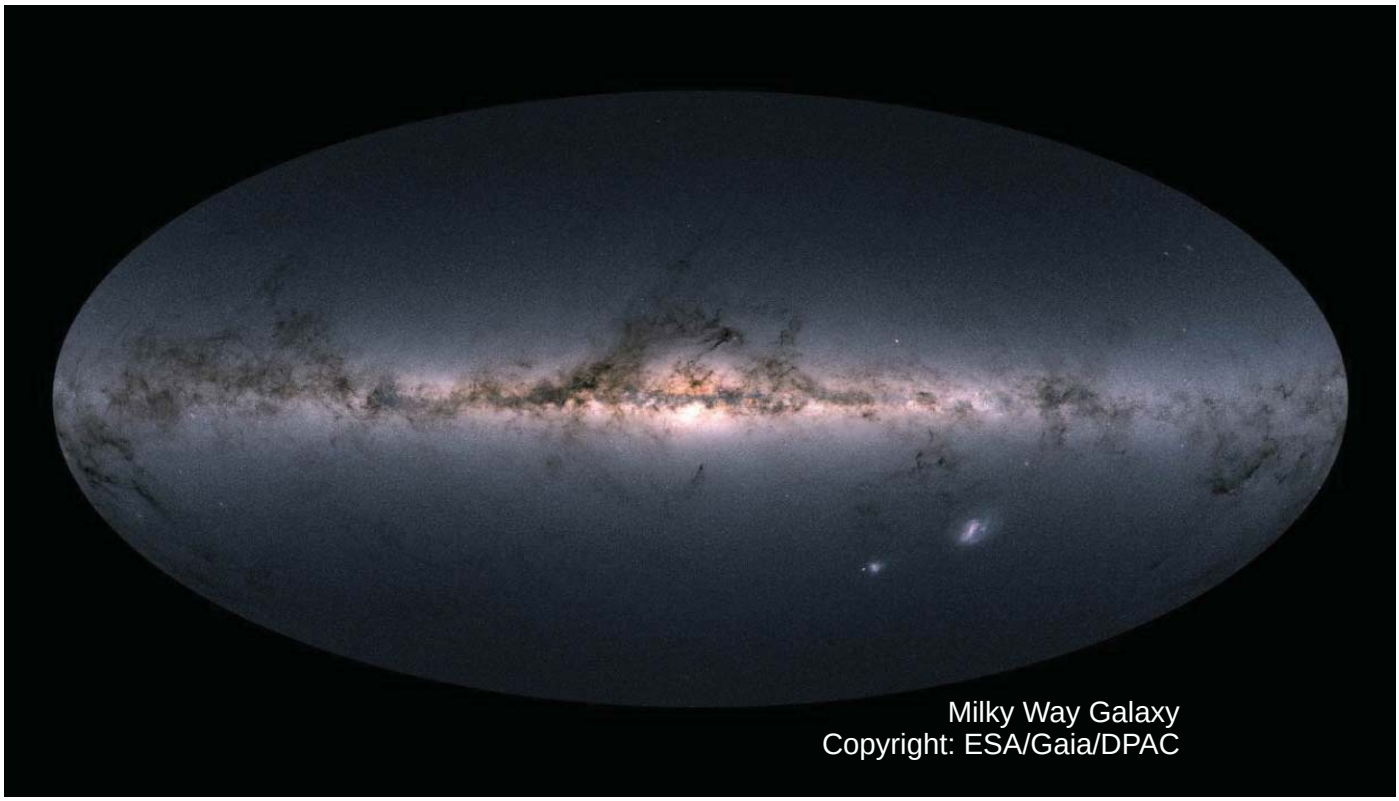


Rim of Korolev Crater
Copyright ESA/Roscosmos/CaSSIS

mission, which concluded in 1993, to create a detailed, 3-D map of the galaxy. ESA has recently released its second catalogue of data from Gaia, including the motion of 7 million stars in three dimensions and another 1.4 billion in two dimensions. A final set of data is expected to be released in 2020 and will include information on the chemical makeup of the stars (from their spectra).

Along with the data release, ESA created a map of our galaxy based upon the information gathered on nearly 1.7 billion stars. The map portrays both the brightness and color of the stars included in the survey. The Large and Small Magellanic Clouds (dwarf galaxies) can be seen below the galactic plane.

The data catalogue also includes information on more than 14,000 solar system objects (mostly asteroids), 500,000 variable sources, objects outside the Milky Way Galaxy (including more than one-half million quasars), including twelve nearby dwarf galaxies, and 75 globular clusters that orbit our galaxy. The data on the motion of stars is expected to be beneficial in mapping the distribution of dark matter within our galaxy.

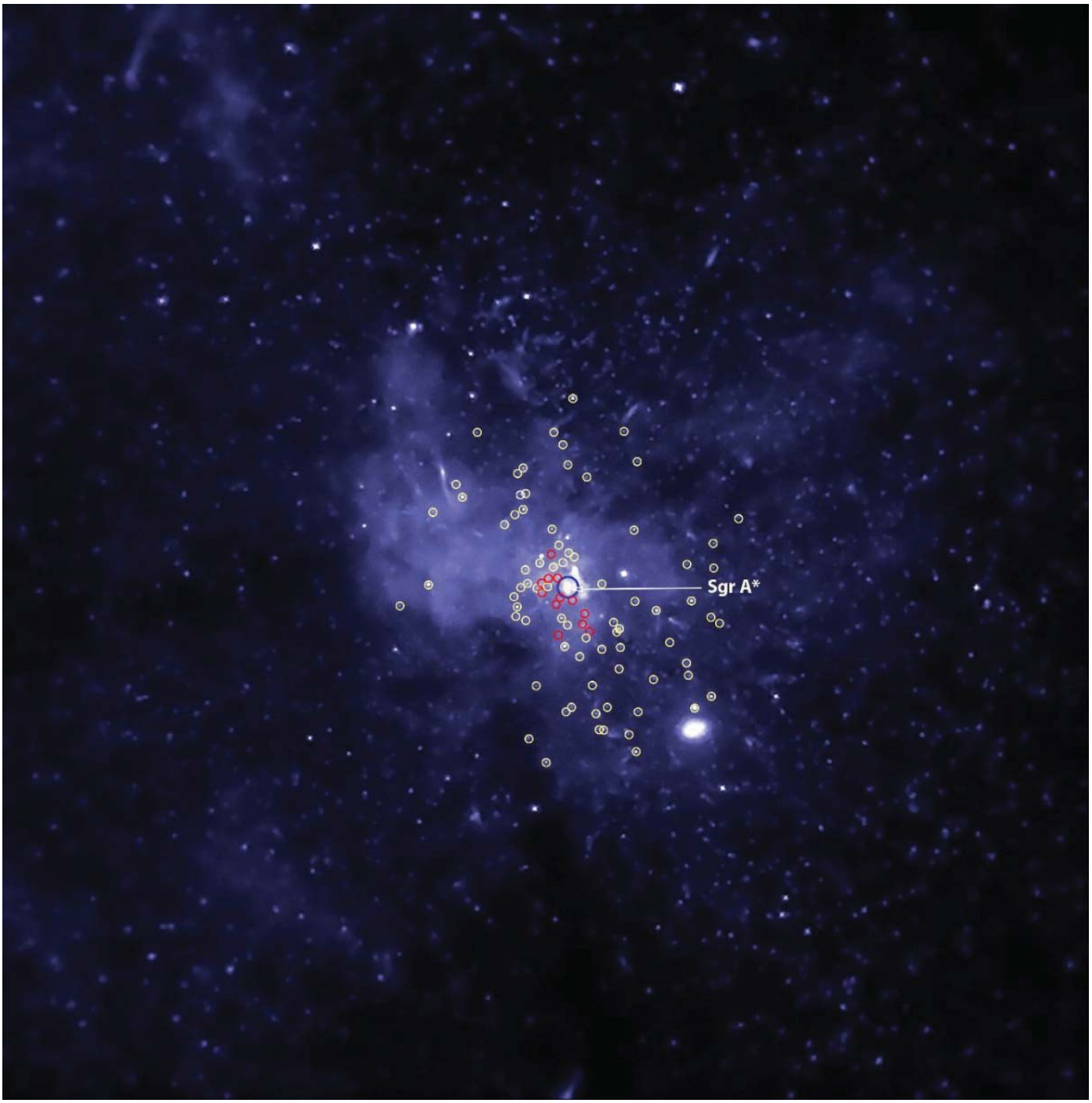


Milky Way Galaxy
Copyright: ESA/Gaia/DPAC

Black Hole News

Astronomers believe that a supermassive black hole can be found in most, if not all, spiral galaxies. The supermassive black hole at the center of the Milky Way Galaxy, Sagittarius A* (Sgr A*), is estimated at more than 4 million times the mass of our Sun. At approximately 26,000 light years distant, Sgr A* is close enough to be observed with instruments such as NASA's Chandra X-ray Observatory. While black holes are invisible, their location is revealed by the X-rays emissions from the gas and dust being pulled into the black hole.

The mass of a black hole can be determined from its effect on nearby space, in particular, stars in orbit around the black hole or passing by. This year, astronomers will have the opportunity to observe the star S0-2, one of the two stars that comes the closest to the Sgr A* in their highly elliptical orbits. S0-2 completes an orbit around Sgr A* every 16 years, coming as close to the black hole as 17 light hours (about 4 times the distance from the Sun to Neptune). The close encounter will enable astronomers to test Einstein's theory of general relativity, as the light from S0-2 will be affected (stretched or redshifted) by the black hole's strong gravitational field. Among the other questions astronomers are hoping to answer is how a relatively young star (as well as other nearby stars) could form in a region so disrupted by the tidal forces of a supermassive black hole (next page:).



The red colored circle are X-ray binaries that likely contain a black hole. The yellow colored circles are likely binaries containing white dwarf stars. Image credit: NASA/CXC/Columbia Univ./C. Hailey et al.

In other black hole news: theoretical studies suggest that stellar mass black holes could migrate, over time, towards the center of a galaxy and the supermassive black hole. Observational data from the Chandra is now being used to test that theory. Preliminary indications are that there may be as many as 20,000 black holes (five to 30 times the mass of the Sun), located in and scattered around the Milky Way's core.

A team from Columbia University in New York searched through the Chanda data for X-ray spectra consistent with a black hole (verses other high energy X-ray sources such as neutron stars) within 12 light years of Sgr A*. They were able to confirm the presence of two black holes within three light years of the supermassive black hole (closer than the nearest star system is to our Sun). Since only the brightest X-ray sources are visible to us, it is believed that there are many fainter candidates in the galactic core region beyond our current means of detection.

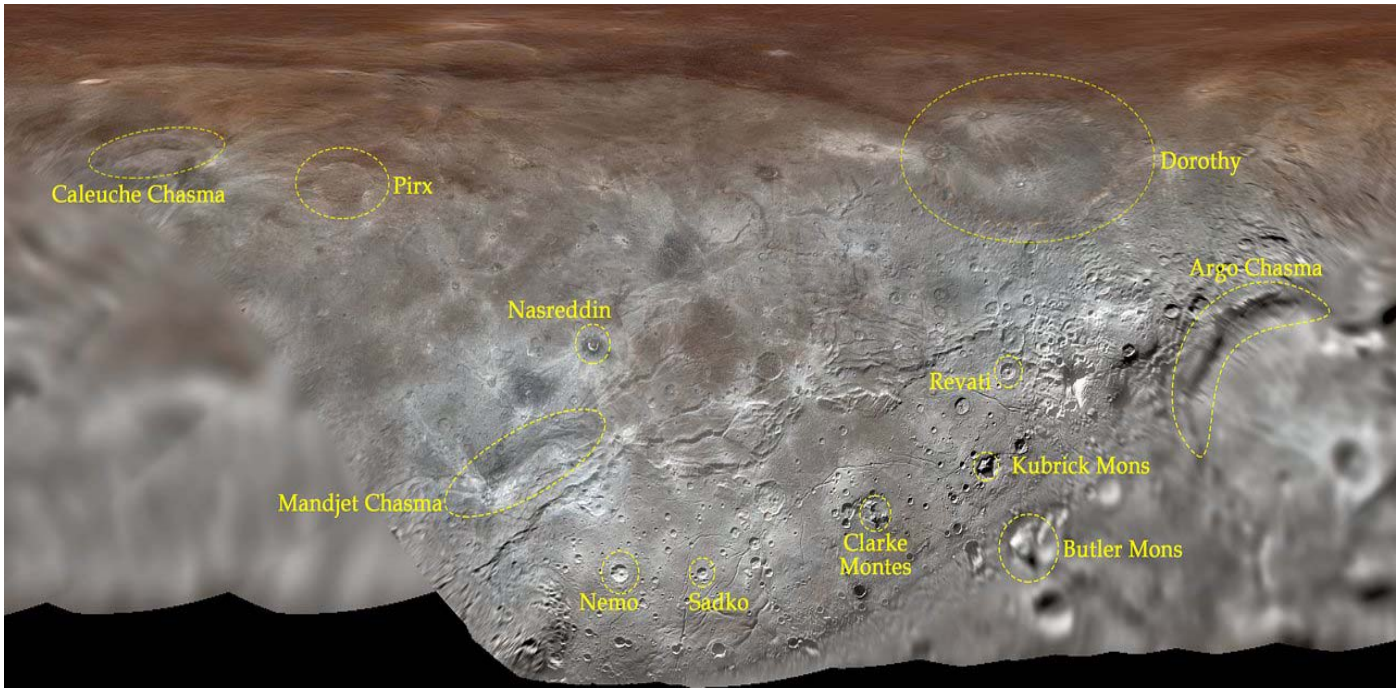
Charon Lexicon

On July 14, 2015, NASA's New Horizons spacecraft successfully completed a high speed pass of Pluto and its five moons before heading out into the Kuiper Belt (where it will encounter its next target on January 1, 2019). The science team, led by Dr. Alan Stern identified many of the more prominent features (e.g., mountains, plains, valleys and craters) with unofficial designations.

The International Astronomical Union, the recognized authority on naming conventions and their approval, recently sanctioned a dozen names, proposed by the New Horizons team, for surface features on Pluto's largest moon Charon.

The approved names are Argo Chasma, Butler Mons, Caleuche Chasma, Clarke Montes, Dorothy Crater, Kubrick Mons, Mandjet Chasma, Nasreddin Crater, Nemo Crater, Pirx Crater, Revati Crater, and Sadko Crater. The approved names include fictional explorers and adventurers, science fiction personalities, mythology, and visionaries such as Clarke and Kubrick.

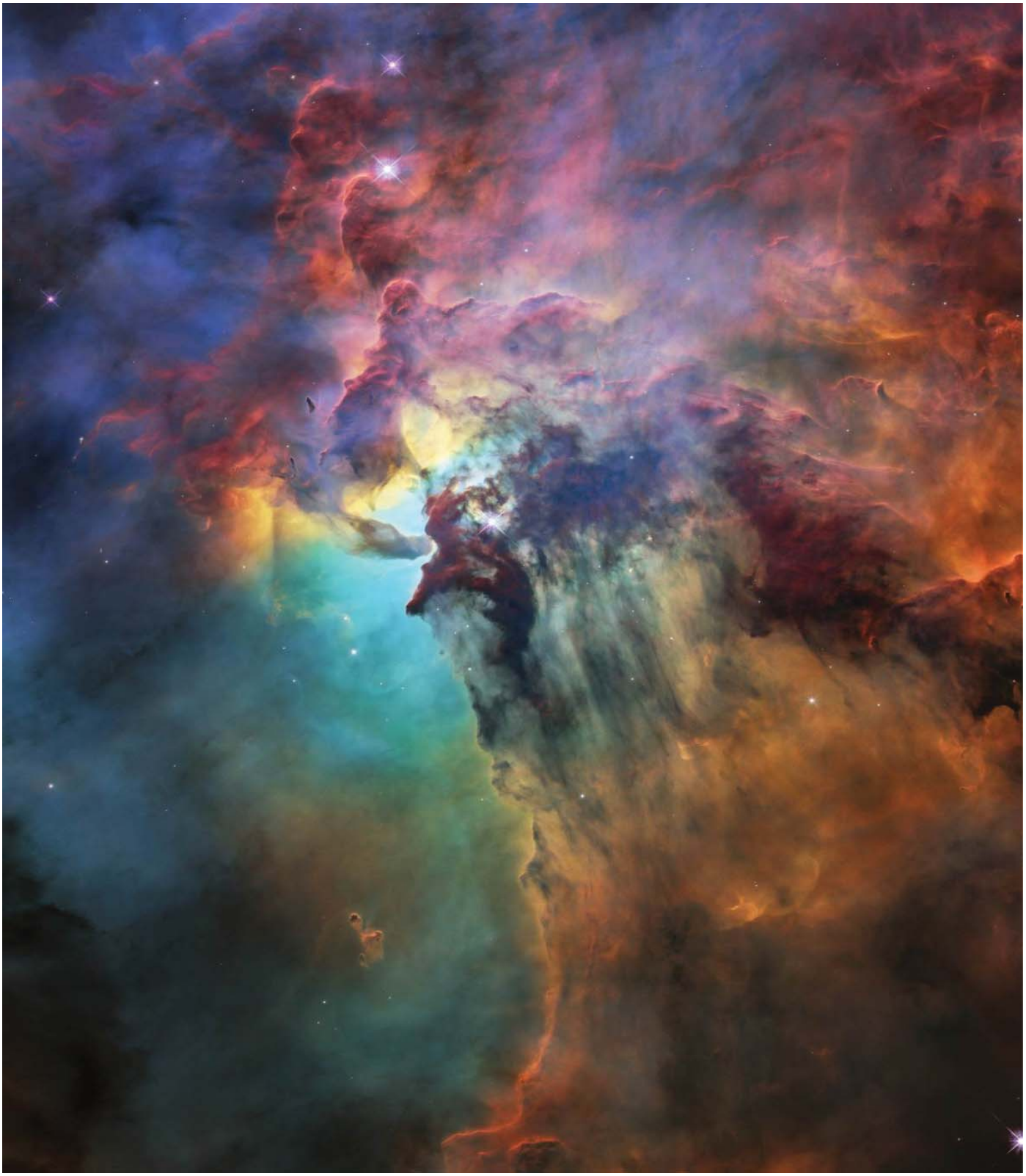
Enhanced color image of Charon from New Horizons
Credit: NASA/JHUAPL-SwRI



Map projection of Charon, the largest of Pluto's five moons, annotated with its first set of official feature names. With a diameter of about 1215 km, the France-sized moon is one of largest known objects in the Kuiper Belt, the region of icy, rocky bodies beyond Neptune.
Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

The Hubble Space Telescope Celebrates 28 Years

The Hubble Space Telescope celebrated its 28th anniversary with the release of an image of the Lagoon Nebula in the constellation Sagittarius. The image captured only a small portion of the nebula, about 4 light years across. The vast interstellar cloud of gas and dust covers an area 55 light years by 20 light years, and is approximately 4,000 light years away from Earth (a light year is approximately 93 million miles) in the direction of the center of the galaxy.



The image was compiled from observations between February 12th and the 18th, and captured by the telescope's Wide Field Camera 3. The camera had been installed during the last shuttle servicing mission (Service Mission 4), launched on May 11, 2009. It has two channels, one for ultraviolet and visible light and the other for near-infrared. Its infrared sensitivity allows astronomers to study newly-formed, hot stars still shrouded in dust in this vast nursery.

Dust Hazards

The Moon's surface is covered with a layer of pulverized rock and dust, called regolith. The fine particles on the lunar surface are bombarded by the solar wind, a barrage of charged particles from the Sun, which can impart an electrical charge. Research has shown that charged dust particles can levitate and even move across the surface. Apollo astronauts also experienced the "static cling" of moondust.

Schmitt, and the other Apollo astronauts report sneezing, watery eyes and a sore throat when exposed to the dust carried into the Lunar Module on their spacesuits. The symptoms were relatively short-lived with the astronaut's brief stay on the lunar surface.

A new study suggests, however, that breathing lunar dust for a prolonged period of time could pose a major health risk. The study, conducted by Stony Brook University School of Medicine in Stony Brook, New York, found that exposure to simulated lunar soil (volcanic fines small enough to be inhaled and with the same chemical and physical properties as the lunar regolith) was toxic to human lung cells and mouse brain cells, killing up to 90 percent of the cells and neurons.

A dust covered Harrison Schmitt, Apollo 17 astronaut and geologist
Photo Credit: NASA/Gene Cernan

The Stony Brook study builds on previous research that delves into an insidious threat confronting astronauts and future colonists on arid worlds such as the Moon and Mars.

Summer Solstice

On the morning of June 21st the Sun will rise over a prehistoric structure on the Salisbury Plain in southern England as it has for the last 4,000 years. For those individuals standing within the 100 foot diameter circle of 30 sandstone or sarsen-stones (weighing up to 50 tons each), the Sun will appear over a large naturally shaped stone (Heel Stone) located outside and to the northeast of the circle. The alignment signals the start of the longest day, midsummer, or the summer solstice.

The photo (at top right next page) shows the current state of the stone circle. Many of the original stones are missing or damaged. Over time, they were taken to build houses and roads, chipped away by visitors and taken as souvenirs. What remains represents the last in a progressive sequence of monuments erected at the site between 3,000 and 1,600 B.C. The Heel Stone is adjacent to the access road to the site. The ancient people who constructed this monument left no written record of their accomplishments or the intended use of the stone circle. Its purpose has been widely debated and many groups have attempted to claim ownership. However, archeologists have clearly shown that the construction of Stonehenge predates the appearance of most modern cultures in Britain.

In the 1960s, Gerald Hawkins, an astronomer at the Smithsonian Astrophysical Observatory, found that each significant stone aligns with at least one other to point to an extreme position of the sun or moon ("*Stonehenge*

Stonehenge
Photo: Bill Cloutier

Heel Stone
Photo: Bill Cloutier

Decoded,"Doubleday&Company).That Stonehenge is an astronomical observatory or celestial calendar is intriguing, as the precision and architectural refinement by which it was constructed certainly suggests a significant purpose for this megalithic monument.

June History
Women in Space

On June 16, 1963, Valentina Tereshkova became the first woman in space. Shortly after Yuri Gagarin's flight, the Soviets began a search for suitable female candidates for spaceflight. With few female pilots, the majority of the candidates were women parachutists (Valentina had joined an amateur parachuting club at the age of 18). Control of the Vostok spacecraft was completely automatic, so piloting experience was not required. However, since the Vostok was not designed to return its occupant safely to Earth, the cosmonaut was required to eject from the spacecraft after re-entry and parachute to the landing site.

The selection of Valentina Tereshkova for the flight was made by Premier Khrushchev. In addition to experience and fitness, qualifications included being an ideal Soviet citizen and model Communist Party member. On June 16th, Valentina rode Vostok 6 into orbit with the call sign "Chaika" (Seagull). The mission was not without incident and included space-sickness, leg cramps and other discomforts from being strapped into the capsule for three days. More importantly, the capsule ended up in the wrong orientation and, had it not been corrected, would not have allowed her to return to Earth.

Valentina's three days in space was more flight time than all the American astronauts combined (at that time). After fulfilling her duties to her country, Tereshkova retired to a small house on the outskirts of Star City. The house is topped with a seagull weathervane, the call sign of her flight.

Twenty years later on June 18th, Sally Ride became the first American woman in space. Launched aboard the space shuttle Challenger, Sally served as the mission specialist on the five person crew.

An Extraordinary Feat

If you have ever seen a Gemini space capsule (there is one on display at the Air and Space Museum in Washington, D.C.) it is difficult to comprehend how two people could have spent any length of time inside its cramped

NASA Photo

interior (Frank Borman and Jim Lovell spent 14 days orbiting the Earth in Gemini 7). The reentry module, where the two astronauts sat, is approximately 11 feet long with a maximum diameter of 7½ feet and filled with nstrumentation, life support systems and controls.

On June 3, 1965, Gemini 4 lifted off on a four day mission. The highlight of the mission was to be a spacewalk by Ed White. NASA was very concerned with "putting guys in vacuums with nothing between them but that little old lady from Worcester, Massachusetts [the seamstress at the David Clark Company], and her glue pot and that suit." However, the Soviets had challenged the United States with a spacewalk by Cosmonaut Alexei Leonov in March during a Voskhod II mission, and the United States did not want to appear to be falling behind its adversary.

After struggling with a faulty hatch, Ed White finally exited the spacecraft as it passed over the Pacific Ocean. Using a gun powered by compressed oxygen, he was able to maneuver outside the capsule, just avoiding the flaming thrusters of the Gemini capsule. After a 23 minute spacewalk, Jim McDivitt struggled to get the six foot tall Ed White back inside the capsule and close the balky door.

Unfortunately, after making history as the first American to walk in space, Ed White died during a launch pad test of the Apollo 1 spacecraft when the pure oxygen atmosphere exploded, killing all three astronauts inside.

Jupiter and its Moons

Jupiter reached Opposition in early May when the two planets were at their closest. During the month of June, Jupiter is still well placed in evening sky after sunset. Jupiter will be at its highest approximately 2-1/2 hours after sunset on June 1st (11 pm) and almost two hours earlier by month's end. As the Earth moves ahead of Jupiter on its inside orbit, Jupiter will diminish slightly in brightness and apparent size. As one of the brightest star-like objects in the night sky, Jupiter can be found in the constellation Libra.

Double Jovian Moon Transit
Photo: Bill Cloutier

One of the more interesting and easier events to observe through a telescope is the projection of a shadow from one of Jupiter's moons on the Jovian disk as the moon passes in front of (or transits) the planet. On nights of good visibility the following events should be visible through a moderately-sized telescope.

Jovian Moon Transits

Date	Moon	Transit Begins	Transit Ends
8th	Io	7:30 pm	9:40 pm
13th	Europa	8:21 pm	10:36 pm
15th	Io	9:25 pm	11:34 pm
20th	Europa	10:58 pm	1:13 am (21st)
22nd	Io	11:19 pm	1:28 am (23rd)
25th	Ganymede	8:59 pm	10:43 pm

Red Spot Transits

The Red Spot is a large cyclone in the upper Jovian atmosphere. The rapid rotation of this gas giant (10 hours) may be responsible for the longevity of this storm, which has been observed for over 300 years. The Red Spot will cross the center line of the planetary disk on the following evenings during the hours between 8 pm to midnight local time):

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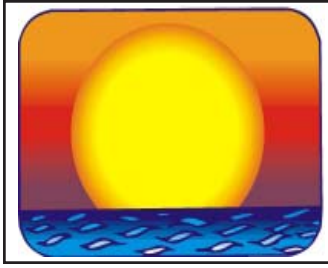
Date	Transit Time	Date	Transit Time
1st	9:13 pm	15th	10:45 pm
3rd	10:52 pm	18th	8:15 pm
6th	8:21 pm	20th	9:53 pm
8th	9:59 pm	22nd	11:32 pm
10th	11:38 pm	25th	9:02 pm
13th	9:07 pm	27th	10:40 pm



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
June 1st (EDT)	05:21	20:21
June 15th (EST)	05:11	20:29
Juner 30th	05:23	20:31

For the more adventurous and sleep deprived individuals, the summer sky sparkles as twilight deepens and the summer Milky Way rises. The Milky Way is heralded by the three stars of the summer triangle Vega, Deneb and Altair. Appearing like a gossamer stream of stars, it flows across the night sky, emptying into the constellation Sagittarius. In our light-polluted skies, it may be easier to see on nights when the Moonis absent (in the weeks preceding and following the New Moon on the 13th).

High in the June sky is the constellation Hercules. Shaped like a keystone or trapezoid, Hercules is home to one of the finest globular star clusters in the northern hemisphere. The Great Hercules Cluster (M13) is a collection of several hundred thousand suns located near the galactic core of the Milky Way Galaxy at a distance of approximately 25,000 light years. Hercules rises in the evening after the constellation Boötes with its bright star Arcturus and before the constellation Lyra with its bright star Vega. The cluster can be found on the side of the keystone asterism facing Boötes.

Astronomical and Historical Events

1st History: final landing of Space Shuttle Endeavour (STS-134) (2011)
1st History: launch of the ROSAT (Röntgen) X-ray observatory; cooperative program between Germany, the United States, and United Kingdom; among its many discoveries was the detection of X-ray emissions from Comet Hyakutake (1990)
2nd Moon at apogee (furthest distance from Earth)
2nd Apollo Asteroid 2016 XF near-Earth flyby (0.077 AU)
2nd Asteroid 243 *Ida* closest approach to Earth (1.969 AU)
2nd History: launch of the Mars Express spacecraft and ill-fated Beagle 2 lander (2003)
2nd History: launch of the Space Shuttle Discovery (STS-91); ninth and final Mir docking (1998)
2nd History: launch of Soviet Venus orbiter Venera 15; side-looking radar provided high resolution mapping of surface in tandem with Venera 16 (1983)
2nd History: Surveyor 1 lands on the Moon (1966)
2nd History: Gemini 5, Gemini 11, Apollo 12 and Skylab 2 astronaut Pete Conrad born (1930)
2nd History: discovery of Comet Donati by Italian astronomer Giovanni Battista Donati; brightest comet of the 19th century and first comet to be photographed (1858)
3rd History: discovery of two rings around the centaur asteroid 10199 *Chariklo*, the smallest known object to have rings (2013)
3rd History: launch of Gemini 4; Ed White becomes first American to walk in space (1965)
3rd History: launch of Gemini 9 with astronauts Thomas Stafford and Eugene Cernan (1966)
3rd History: dedication of the 200-inch Hale Telescope at Palomar Mountain (1948)
4th Asteroid 17656 *Hayabusa* closest approach to Earth (1.690 AU)
4th Apollo Asteroid 4257 *Ubasti* closest approach to Earth (1.751 AU)
4th Kuiper Belt Object 278361 (2007 JJ43) at Opposition (39.991 AU)
4th History: discovery of Classical Kuiper Belt Object 50000 *Quaoar* by Mike Brown and Chad Trujillo from images acquired at the Samuel Oschin Telescope at Palomar Observatory (2002)
4th History: maiden flight of SpaceX's Falcon 9 rocket; launched from Cape Canaveral, Florida (2010)
5th Apollo Asteroid 2004 LB near-Earth flyby (0.092 AU)
5th Apollo Asteroid 11885 *Summanus* closest approach to Earth (1.326 AU)
6th Last Quarter Moon
6th Scheduled launch of a Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan, with the next Expedition crew to the International Space Station
6th History: launch of Soviet Venus orbiter Venera 16; side-looking radar provided high resolution mapping of surface in tandem with Venera 15 (1983)
7th Aten Asteroid 2017 EH1 near-Earth flyby (0.096 AU)
7th Apollo Asteroid 4769 *Castalia* closest approach to Earth (1.206 AU)
8th History: New Horizons spacecraft, on its way to Pluto, crosses the orbit of Saturn (2008)
8th Apollo Asteroid 4660 *Nereus* closest approach to Earth (1.743 AU)
8th Kuiper Belt Object 2010 KZ39 at Opposition (45.036 AU)
8th History: discovery of Nova Aquila; a supernova explosion from the collapse of a white dwarf (1918)
8th History: launch of Soviet Venus orbiter/lander Venera 9; transmitted the first black and white images of the surface of Venus (1975)
8th History: Giovanni Cassini born, observer of Mars, Jupiter and Saturn (1625)
9th **Second Saturday Stars/Open House at the McCarthy Observatory 8:00 to 10:00 pm**
9th Amor Asteroid 2009 SK104 near-Earth flyby (0.081 AU)
9th Apollo Asteroid 4197 *Morpheus* closest approach to Earth (1.770 AU)
9th History: dedication of the Kathleen Fischer Sundial at the McCarthy Observatory (2012)
10th History: launch of Mars Exploration Rover A (Spirit) in 2003

10th History: launch of Explorer 49, Moon orbiter and radio astronomy explorer (1973)
11th Amor Asteroid 2018 EJ4 near-Earth flyby (0.015 AU)
11th Amor Asteroid 2015 DP155 near-Earth flyby (0.023 AU)
11th Apollo Asteroid 2008 LA near-Earth flyby (0.071 AU)
11th Kuiper Belt Object 174567 *Varda* at Opposition (45.762 AU)
11th History: flyby of Venus by Soviet spacecraft Vega 1 on its way to Comet Halley; dropped off lander and a balloon to study middle cloud layers (1985)
12th History: launch of Venera 4, Soviet Venus lander; first to enter atmosphere of another planet (1967)
13th New Moon
13th History: return of the sample capsule from the Hayabusa (MUSES-C) spacecraft (2010)
14th Moon at perigee (closest distance from Earth)
14th Apollo Asteroid 3361 *Orpheus* closest approach to Earth (0.448 AU)
14th History: first radar astrometry for an asteroid from Goldstone and Haystack antennae observations of the asteroid 1566 *Icarus* (1968)
14th History: launch of Mariner 5; Venus flyby mission (1967)
14th History: launch of Venera 10; Soviet Venus orbiter/lander (1975)
15th Aten Asteroid 2004 LO2 near-Earth flyby (0.064 AU)
15th History: flyby of Venus by Soviet spacecraft Vega 2 on its way to Comet Halley; dropped off lander and a balloon to study middle cloud layers (1985)
16th Aten Asteroid 469737 (2005 NW44) near-Earth flyby (0.055 AU)
16th Apollo Asteroid 2018 BC near-Earth flyby (0.071 AU)
16th Aten Asteroid 2014 GQ17 near-Earth flyby (0.086 AU)
16th Apollo Asteroid 162173 *Ryugu* closest approach to Earth (1.897 AU)
16th Amor Asteroid 3199 *Nefertiti* closest approach to Earth (1.912 AU)
16th History: Liu Yang becomes the first Chinese woman in space aboard a Shenzhou-9 spacecraft, joining two other crew members on a thirteen day mission to the orbiting Tiangong 1 laboratory module (2012)
16th History: Valentina Tereshkova; first woman in space aboard Soviet Vostok 6 (1963)
18th Plutino 28978 *Ixion* at Opposition (38.457 AU)
18th History: launch of the Lunar Reconnaissance Orbiter (LRO) and Lunar CRater Observation and Sensing Satellite (LCROSS) to the Moon (2009)
18th History: Sally Ride becomes the first American woman in space aboard the Space Shuttle Challenger (1983)
19th Asteroid 4 *Vesta* closest approach to Earth (1.142 AU)
19th History: flyby of Earth by the ill-fated Nozomi spacecraft on it way to Mars (2003)
20th History: successful landing of the Viking 1 spacecraft on Mars' Chryse Planitia (Plains of Gold) (1976)
20th First Quarter Moon
20th History: discovery of Nova 1670 in Vulpeculae (1670)
21st Summer Solstice, 10:07 UT (6:07 am EDT)
21st Amor Asteroid 2014 MZ5 near-Earth flyby (0.077 AU)
21st Aten Asteroid 2014 OL339 closest approach to Earth (0.287 AU)
21st Centaur Object 5145 *Pholus* at Opposition (26.850 AU)
22nd Apollo Asteroid 4034 *Vishnu* closest approach to Earth (1.494 AU)
22nd History: launch of Soviet space station Salyut 5 (1976)
22nd History: founding of the Royal Greenwich Observatory (1675)
22nd History: discovery of Pluto's largest moon *Charon* by Jim Christy (1978)
23rd Apollo Asteroid 467309 (1996 AW1) near-Earth flyby (0.046 AU)
23rd Apollo Asteroid 2063 *Bacchus* closest approach to Earth (1.702 AU)
23rd Kuiper Belt Object 50000 *Quaoar* at Opposition (41.882 AU)

24th Aten Asteroid 441987 (2010 NY65) near-Earth flyby (0.019 AU)
24th History: launch of the Salyut 3 Soviet space station (1974)
24th History: Fred Hoyle born; British astronomer and proponent of nucleosynthesis (1915)
24th History: Sir William Huggins makes first photographic spectrum of a comet (1881)
25th History: Rupert Wildt born, German-American astronomer and first to hypothesize that the CO_2 in the Venusian atmosphere was responsible for the trapped heat (1905)
25th History: Hermann Oberth born, father of modern rocketry and space travel (1894)
26th Apollo Asteroid 2007 UD6 near-Earth flyby (0.074 AU)
26th Asteroid 12002 *Suess* closest approach to Earth (1.764 AU)
26th History: Charles Messier born, famed comet hunter (1730)
27th Saturn at Opposition, rising with the setting Sun and visible all night
27th Atira Asteroid 2015 ME131 closest approach to Earth (1.088 AU)
27th History: discovery of the Mars meteorite SAU 060, a small 42.28 g partially crusted grey-greenish stone found near Sayh al Uhaymir in Oman (2001)
27th History: flyby of the asteroid *Mathilde* by the NEAR spacecraft (1997)
27th History: Space Shuttle Atlantis (STS-71) first docking with the Russian space station Mir (1995)
27th History: launch of SEASAT, the first Earth-orbiting satellite designed for remote sensing of the Earth's oceans (1978)
27th History: Alexis Bouvard born, French astronomer, director of Paris Observatory, postulated existence of eighth planet from discrepancies in his astronomical tables for Saturn and Uranus. Neptune was subsequently discovered by John Couch Adams and Urbain Le Verrier after his death where he had predicted (1767)
28th Full Moon (Strawberry Moon)
28th Scheduled launch of a SpaceX Dragon cargo-carrying spacecraft from the Kennedy Space Center, Florida, to the International Space Station
28th Amor Asteroid 7088 *Ishtar* closest approach to Earth (1.738 AU)
28th History: discovery of Pluto's moon *Kerberos* by Mark Showalter, et al., using the Hubble Space Telescope (2011)
28th History: Nakhla meteorite fall in Egypt (Mars meteorite), a piece of which was claimed to have vaporized a dog; first direct evidence of aqueous processes on Mars (1911)
29th Moon at apogee (furthest distance from Earth)
29th Apollo Asteroid 10563 *Izhdubar* closest approach to Earth (0.738 AU)
29th History: George Ellery Hale born, founding father of the Mt. Wilson Observatory (1868)
30th History: discovery of *Haume*a's moon *Namaka*, the smaller, inner moon of the dwarf planet, by Mike Brown, Chad Trujillo, David Rabinowitz, et al. (2005)
30th History: crew of Soyuz 11 dies upon return from the Salyut space station when capsule depressurizes (1971)
30th History: Tunguska Explosion Event (1908)

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

References on Distances

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

" 1 astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station/Iridium Satellites

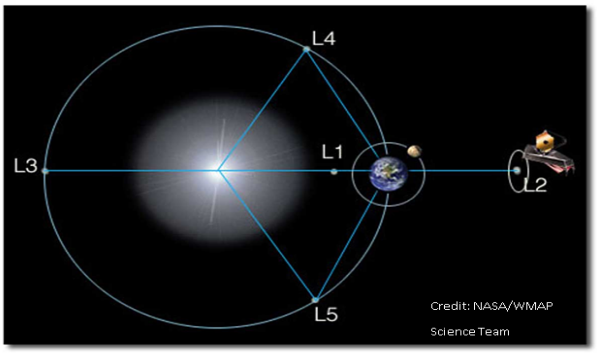
Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

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.

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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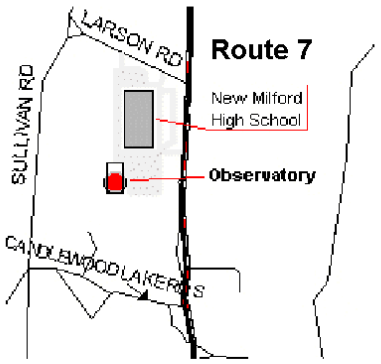

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Eagle Nebula image by Marc Polansky

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- ★ Day 1: The Origin of Astronomy
- ★ Day 2: Astronomy in the Renaissance
- ★ Day 3: Einstein and Newton
- ★ Day 4: Hubble, Galaxies, and the Astounding Expanding Universe
- ★ Day 5: The Big Bang Theory
- ★ Day 6: Observation Night – Parents welcome! Students will observe objects they've studied during the week and show off what they've learned.

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$$\Omega = \frac{3GM}{2c^2R^3}(R\times v) + \frac{GJ}{c^2R^3}\left[\frac{3R}{R^2}(\omega\cdot R) - \omega\right]$$

Geodetic Precession — Frame-dragging Precession

$$S = \frac{\pi A k c^3}{2hG}$$

June 9th

8:00 - 10:00 pm

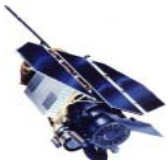
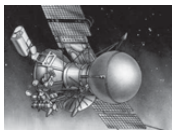
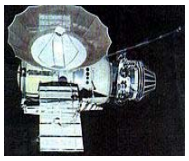
ASTRONOMY

It's More Down to Earth Than You Think

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

June 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Phases of the Moon  June 6 June 13 June 20 June 28					1  Launch of Mars Express spacecraft and ill-fated Beagle 2 lander. (2003)	2  Moon at Apogee (farthest from earth) Launch of Soviet Venus Orbiter, Venera 15 to map surface of Venus, in tandem with Venera 16 (1983)   Launch of ROSAT (Röntgen) X-ray observatory (1990)
3 200-inch Hale Telescope dedication (1948)   Gemini 9 launch, Thomas Stafford, Eugene Cernan. (1966) Launch of Gemini 4; Ed White 1st American to walk in space (1965) 	4  Maiden flight of Space X Falcon 9 rocket (2010)	5  Mercury-Redstone 3, or Freedom 7, first US human spaceflight, on May 5, 1961, piloted by astronaut Alan Shepard	6  Venera 16 - last of Soviet Venus orbiter/ lander missions to map Venusian landscape (1983)	7  "Three flames ate the sun, and big stars were seen." - etching on Chinese oracle bones indicating ancient solar eclipse, with three coronal streamers and stars visible in the darkened sky. (1302 BC)	8  Giovanni Cassini born, observer of Mars, Jupiter and Saturn (1625)  Launch of Venera 9, - 1st black/white images of surface of Venus (1975)	9 Dedicationof the Kathleen Fischer Sundial at the McCarthy Observatory (2012)  Johann Gottfried Galle, German astronomer, born - first to view planet Neptune, using calculations of Urbain Le Verrier 1846. (1812)   2nd Saturday Stars Open House McCarthy Observatory
10  Launch of Explorer 49 - moon orbiter and radio astronomy explorer (1973) Launch of Mars Exploration Rover A Spirit (2003) 	11  Flyby of Venus by Soviet spacecraft Vega 1 on its way to Comet Halley - dropped off lander and a balloon to study middle cloud layers (1985)	12  Launch of Venera 4, Soviet Venus lander, first to enter orbit of another planet (1967)	13  Return of sample capsule from the Hayabusa (MUSES-C) spacecraft, taken from near-Earth asteroid Itokawa (2010)	14  Launch of Mariner 5, Venus flyby mission (1967) Launch of Venera 10, Soviet Venus orbiter/ lander (1975)	15  Moon at perigee (closest distance to Earth)  flyby of Venus by Soviet spacecraft Vega 2 on its way to Comet Halley; dropped off lander and a balloon to study middle cloud layers (1985)	16  Liu Yang becomes the first Chinese woman in space (2012) Valentina Tereshkova, 1st woman in space (1963) 
17  Discovery of the Dhofar 378 Mars meteorite (2000)	18  Sally Ride, 1st U.S. woman in space (1983) Launch of Lunar Reconnais-sance Orbiter and LCROSS satellite to Moon (2009) 	19  Flyby of Earth by the ill-fated Nozomi spacecraft on its way to Mars (2003)	20  Discovery of Nova 1670 in Vulpeculae by Pere Dom Voiture Anthelme, a Carthusian monk in Dijon, France (1670)	21 Summer Solstice 05:04 UT (1:04 AM EDT)   Yáng Lìwei, a Chi-nese major general, military pilot and a CNSA astronaut; was first man sent into space by the Chi-nese space program and his mis-sion, Shenzhou 5, made China the third country to independently send people into space (1965)	22  Royal Greenwich Observatory founded (1675) Discovery of Pluto's largest moon Charon by Jim Christy (1978)   Launch of Soviet space station Salyut 5 (1976)	23  Martin John Rees born, British cosmologist and astrophysicist, has contributed to knowlege of the cosmic background radiation, galaxy clustering and formation, and on the final disproof of Steady State theory. (1942)
24 Fred Hoyle born, British astronomer and proponent of nucleosynthesis (1915)   Sir William Huggins makes 1st photographic spectrum of a comet (1881)	25 Rupert Wildt born, German astronomer (1905) Hermann Oberth born, father of modern rocketry and space travel (1894)	26 Charles Messier born, famed comet hunter (1730) German astronomer Walter Baade discovers near-earth asteroid 1566 Icarus inside orbit of Mercury, which became the subject of asteroid-busting "project Icarus." (1949) 	27 Alexis Bouvard born,postulated existence of 8th planet, later identified as Neptune (1767) launch of SEASAT 1, first Earth-orbiting satellite designed for remote sensing of oceans (1978) Flyby of the asteroid Mathilde by the NEAR spacecraft (1997)	28 Nakhla meteor fall in Egypt - A piece of Mars object fabled to have hit dog (1911)	29 George Ellery Hale born, founding father of Mt. Wilson Observatory (1868) Shuttle Atlantis docks with Russian space station Mir to form the largest man-made satellite ever to orbit the Earth - the second time ships from two countries had linked up in space (1995). 	30 Death of 3 cosmonauts in Soyuz 11 when capsule depressurizes in reentry (1971) Tunguska explosion event (1908) Leap second added to world clocks