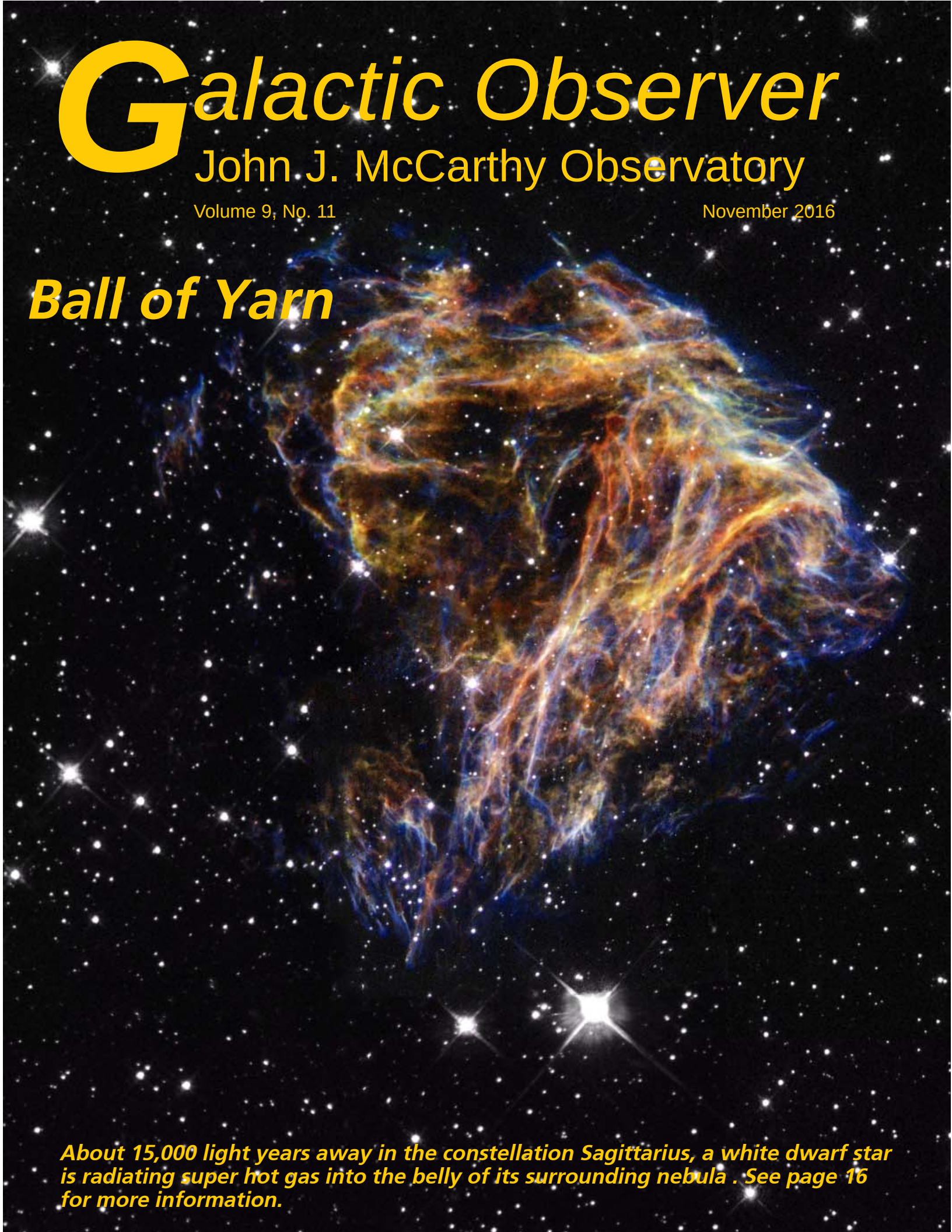
Galactic Observer

John J. McCarthy Observatory

Volume 9, No. 11 November 2016

Ball of Yarn



About 15,000 light years away in the constellation Sagittarius, a white dwarf star is radiating super hot gas into the belly of its surrounding nebula . *See page 16 for more information.*

The John J. McCarthy Observatory

New Milford High School
388 Danbury Road
New Milford, CT 06776

Phone/Voice: (860) 210-4117
Phone/Fax: (860) 354-1595
www.mccarthyobservatory.org

JJMO Staff

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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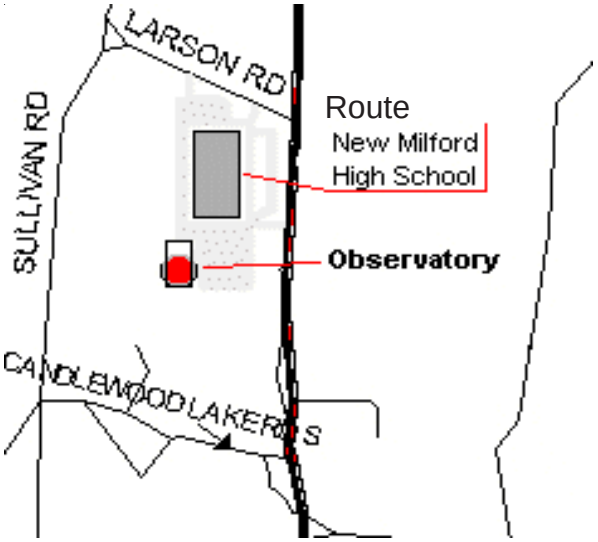
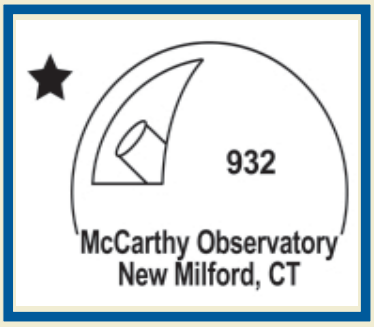


In This Issue



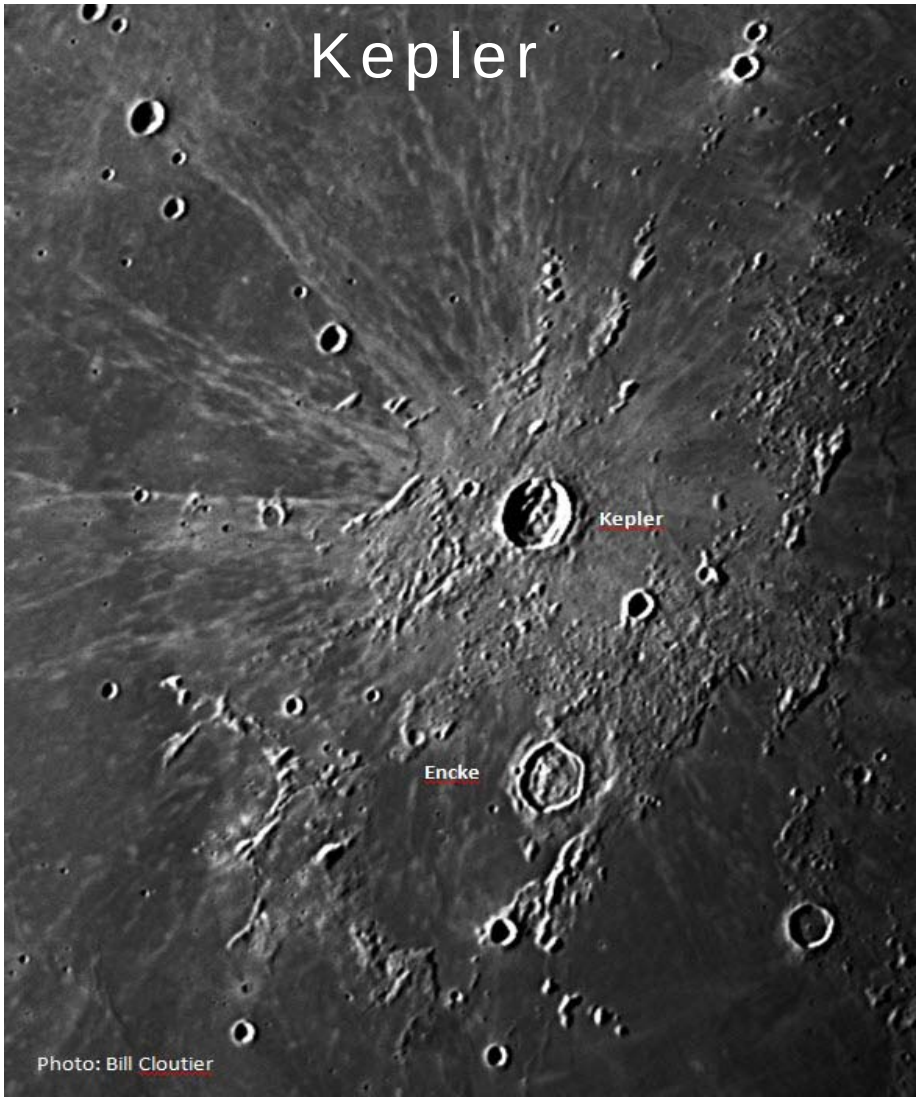
November Astronomy Calendar and Space Exploration Almanac

"Out the Window on Your Left"

IT'S BEEN 44 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).

Kepler lies 300 miles west of the majestic crater Copernicus, in the lava plains between Oceanus Procellarum (Ocean of Storms) to the west and Mare Insularum (Sea of Islands) in the east. Eighteen miles (29.5 km) in diameter, Kepler has a youthful appearance with its bright system of rays extending across the surrounding mare. While a contemporary of Copernicus, and considerably younger than the Imbrium basin impact, sections of Kepler's walls have collapsed over time leaving mounds of rubble on the crater's floor and discontinuities in its rim. The crater's ray system is generally symmetrical, although somewhat suppressed to the east. The



crater's central peaks are offset from center and the southern rim is higher than its northern counterpart. These characteristics suggest that the crater was created by a moderately oblique impact with the impactor arriving from over the northeastern horizon.

Kepler (in the form Keplerus) was the name given to the crater by the Italian astronomer and Jesuit Giovanni Battista Riccioli on lunar maps drawn by colleague and fellow astronomer Francesco Maria Grimaldi. The annotated maps were included in Riccioli's 1651 *Almagestum Novum* (an encyclopedic work covering astronomy and related subjects).

The German astronomer Johannes Kepler used the observational data of Tycho Brahe, a Danish astronomer, to develop his three laws of planetary motion. It's likely not a coincidence that Riccioli took notice that one of the rays from Tycho crater traverses the Kepler crater (Brahe was very protective of his data) in his naming the crater Kepler.

The irregular shaped crater Encke lies to the southeast of Kepler. Named after the German astronomer Johann Franz Encke, who became famous for his calculations that led to the discovery of a family of short-period comets.

Phobos

Unlike Earth's Moon, which is one of the largest natural satellites as compared to the size of its parent body, the moons of Mars are more akin to residents of the asteroid belt. The image (above) of Mars and its larger moon Phobos, taken by the Indian Space Research Organization's Mars Orbiter, shows the diminutive size of the moon.

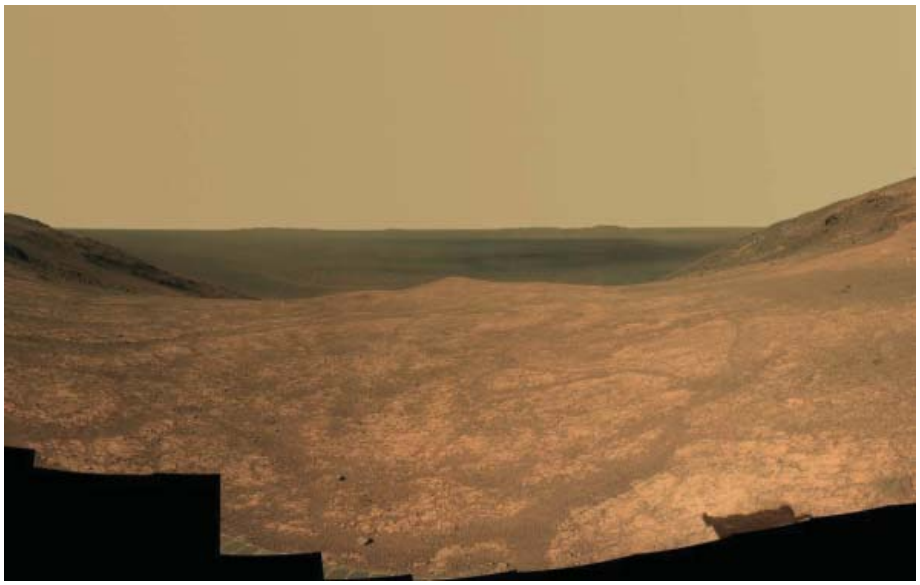
Phobos is an irregular chunk of rock, 10 by 14 by 11 miles (17 by 22 by 18 km). By comparison, Earth's Moon is 2,200 miles in diameter. Phobos orbits Mars at an average distance of 3,700 miles (6,000 km), closer to a planet than any other moon. The moon completes an orbit of Mars in less than 8 hours. Phobos is so close to Mars (and getting closer by 6.6 feet or 2 meters every hundred years), that the planet's gravitational tidal forces are expected to break apart the moon in 30 to 50 million years.

Mars and Phobos (on the limb). Credit: ISRO/ISSDC/ Emily Lakdawalla

Mars Exploration Rover Opportunity

The Opportunity rover, twelve years on the surface, has a new mission and target for exploration. After exploring Marathon Valley, an opening in the western rim of the 14-mile (22 km) diameter crater Endeavor, for the past year the rover is now on the move to a gully that scientists believe may have been carved by flowing water.

The gully is located approximately a half mile (less than a kilometer) to the south, requiring the rover to traverse rugged rim terrain. Opportunity's new mission is expected to last up to two years, a challenge in the harsh Martian environment which will include hunkering down for an eighth winter season in 2017.



Marathon Valley (in approximately true color) looking into the Endeavour crater, with the eastern rim of crater on the horizon Credit: NASA/JPL-Caltech/Cornell Univ./Arizona State Univ.

Long past its 90-day warrantee, Opportunity is still mobile and very capable of navigating the rock-strewn landscape. Its suite of instruments remain functional (for the most part), although issues with its computer's non-volatile memory require the rover to transmit each day's observations before shutting down for the night (or the information is lost). Still the intrepid explorer manages to add miles to the odometer and contribute to our understanding of the Red Planet's past.

The rover has traveled 26.99 miles (43.44 km) since it landed in Eagle crater in 2004. It had been stationary for several days with resources (in orbit and on Earth) dedicated to the Schiaparelli landing (also at Meridiani Planum). Opportunity's camera was positioned in an attempt to capture the descent of Schiaparelli, but the lander did not come into view.

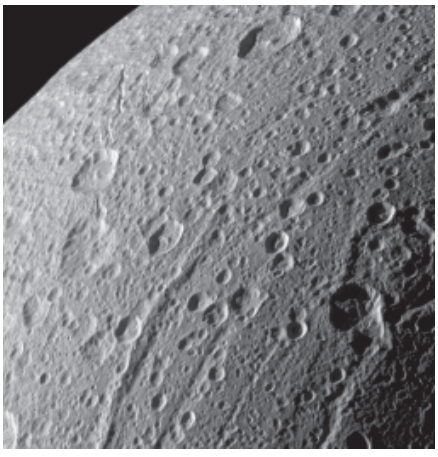
Western Rim of Endeavour Crater. Credits: NASA/JPL-Caltech/Univ. of Arizona

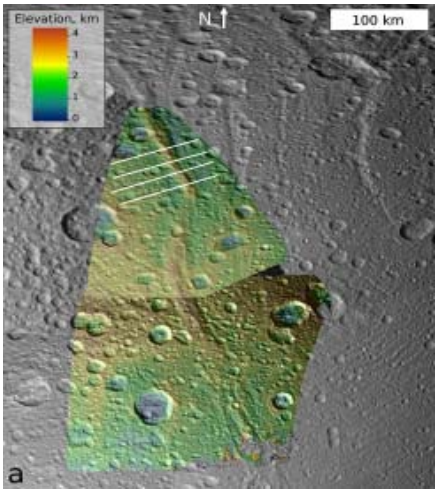
Another Ocean World?

Dione may be the third moon in the Saturnian system to harbor a subterranean ocean. A recent analysis, made possible by the gravity measurements collected by the Cassini spacecraft suggests the presence of a deep, global ocean beneath a thick icy shell. The icy shell covering the ocean is estimated to be about 60 miles (100 km) thick. If confirmed, Dione would join Saturn's moons Enceladus and Titan as water worlds.

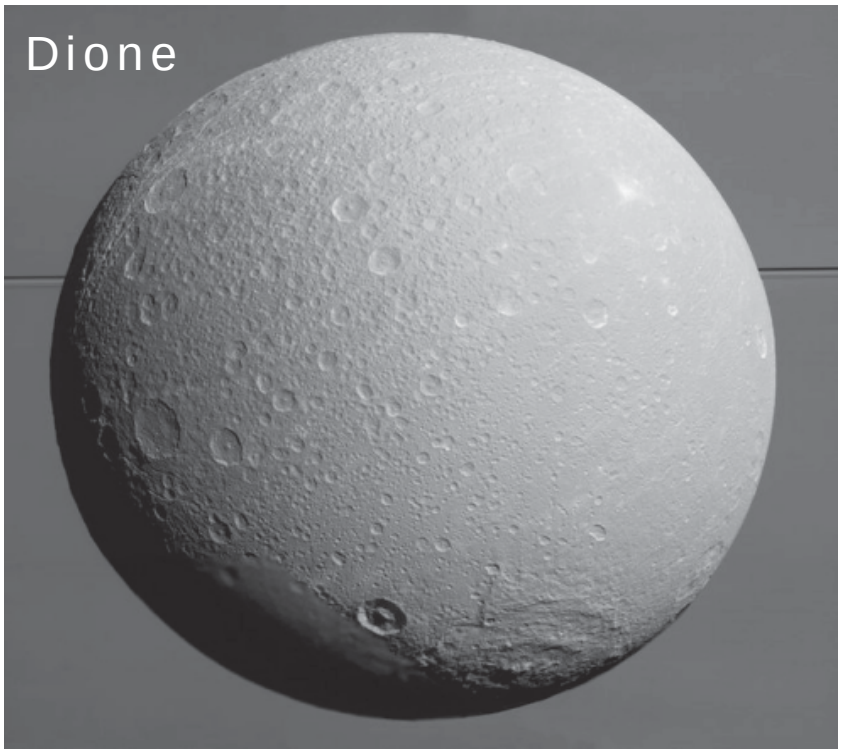
The ocean, potentially tens of miles (kms) deep, is thought to be in contact with the rocky core of the 700-mile-wide (1,120 km) moon. Rock-water interactions are important, in that they can provide the ingredients (nutrients) for life as well as a source of energy.

Similar modeling of the moon Enceladus by the team, led by Mikael Beuthe of the Royal Observatory of Belgium, points to a thinner icy shell than suggested by previous analyses, particularly near the south pole which has active geysers. A thinner shell would facilitate access to the ocean (by probe or submersible).


Janiculum Dorsa, the raised scar in the middle of this Cassini image, is providing new evidence of pressure from a subsurface ocean on Dione. (Source: JPL).



A topographic image of Janiculum Dorsa.. Elevations range from 1 to 2 km (0.6 to 1.2 miles), with blue the lowest and red the highest. This upwelling could be evidence of subsurface warming from an ocean below. Source: NASA/JPL-Caltech/ SSI/Brown

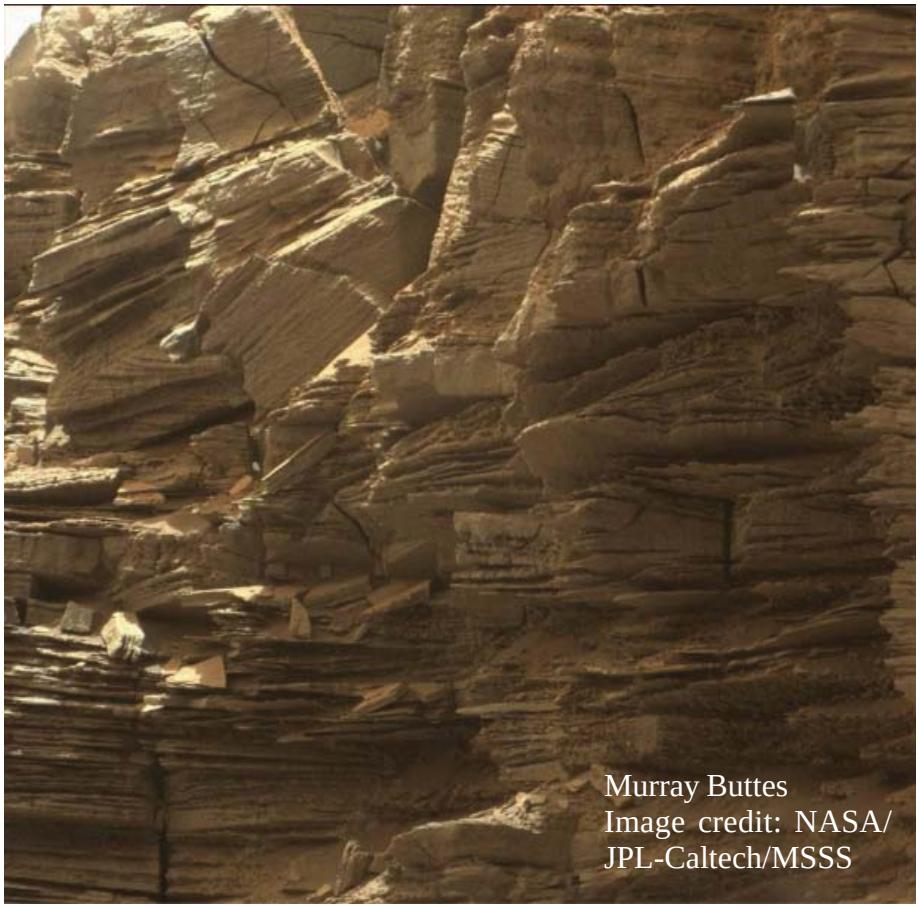


Ascending Mount Sharp

NASA's Mars Science Laboratory Curiosity rover is working its way up through the foothills of Mount Sharp, a mountain central to the Martian crater Gale. The image of finely layered rocks (bottom left) are remnants of wind deposited sandstone (from migrating sand dunes).

The Murray Buttes sandstone geology is different than the mudstone found at other locations that likely formed from ancient lake bed sediments. As the rover climbs in elevation and explores younger layers of the mountain, the presence (or absence) of minerals formed in the presence of water (e.g., hematite and clays) or water-modified features will be used to create a geologic profile of the site and determine the duration that surface water (e.g., river and/or a lake) was present.

The rover has been reconnoitering Gale Crater and Mount Sharp since landing on Mars in August 2012. It has also compiled two Martian years of weather data (e.g., temperature, pressure, ultraviolet light and the water vapor in the air). Curiosity is capable of analyzing soil and drill deposits in-situ with its suite of instruments, including a gas chromatograph, a mass spectrometer and a tunable laser.



Murray Buttes
Image credit: NASA/ JPL-Caltech/MSSS

The Farewell Tour of Cassini

NASA's Cassini spacecraft is now in a polar trajectory in preparation for its final series of orbits dubbed the "Grand Finale." The polar orientation also provides a unique perspective of the gas giant and its rings.

The image (below) is from above the planet, looking down on the night side. It was taken at a distance of approximately 870,000 miles (1.4 million kilometers) from Saturn. The planet's shadow can be seen cutting across the rings. Sunlight reflecting off the rings is illuminating the darkened hemisphere.

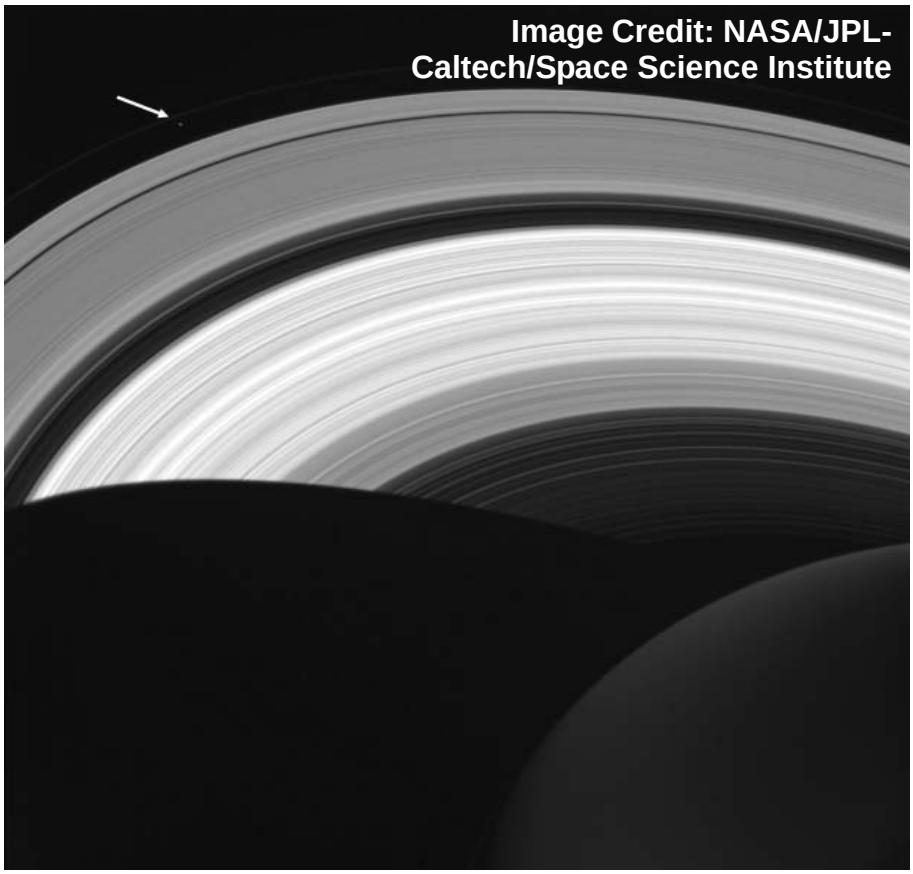
The polar orbit provides unprecedented views of the ring structure and any embedded moons. The diminutive moon Prometheus (53 miles or 86 km across) is visible near upper left (noted with an arrow). The moon was brightened (by a factor of two) to enhance its visibility.

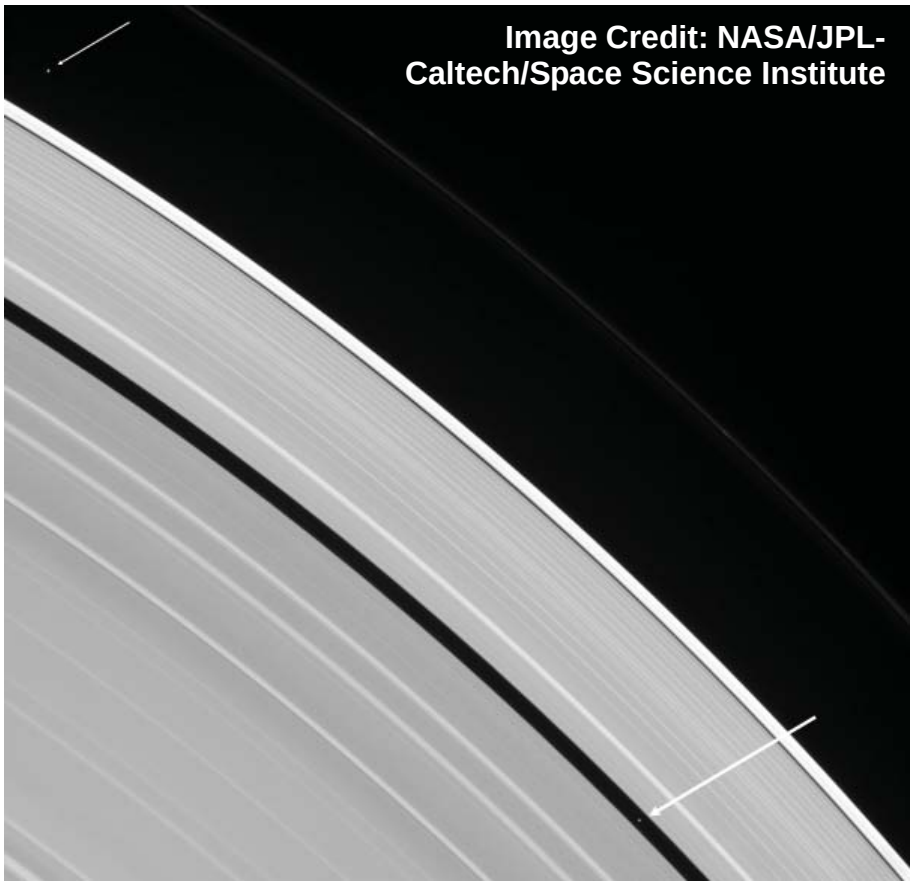
Prometheus acts as a shepherd moon as it travels along the inner edge of Saturn's F-Ring.

The moons Pan and Atlas are visible in this image of the rings. Pan (17 miles or 28 km across) is visible in the lower right. Innermost of Saturn's 62 moons, Pan acts as a shepherd, keeping the Encke Gap open within Saturn's A-Ring. It orbits Saturn every 13.8 hours at a distances of 83,000 miles (134,000 km).

Atlas (upper left) travels along the outer edge of Saturn's A Ring, at a distance of 85,544 miles (137,670 km). The moon is 19 miles (30 km) across and, like Pan, shaped like a flying saucer with an equatorial bulge. It completes an orbit every 14.4 hours.

The image of Pan and Atlas was captured by Cassini's camera from a distance of approximately 3.4 million miles (5.5 million km) from Atlas.





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 17, 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 bright waning gibbous moon (three days after full) may spoil the show.

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.

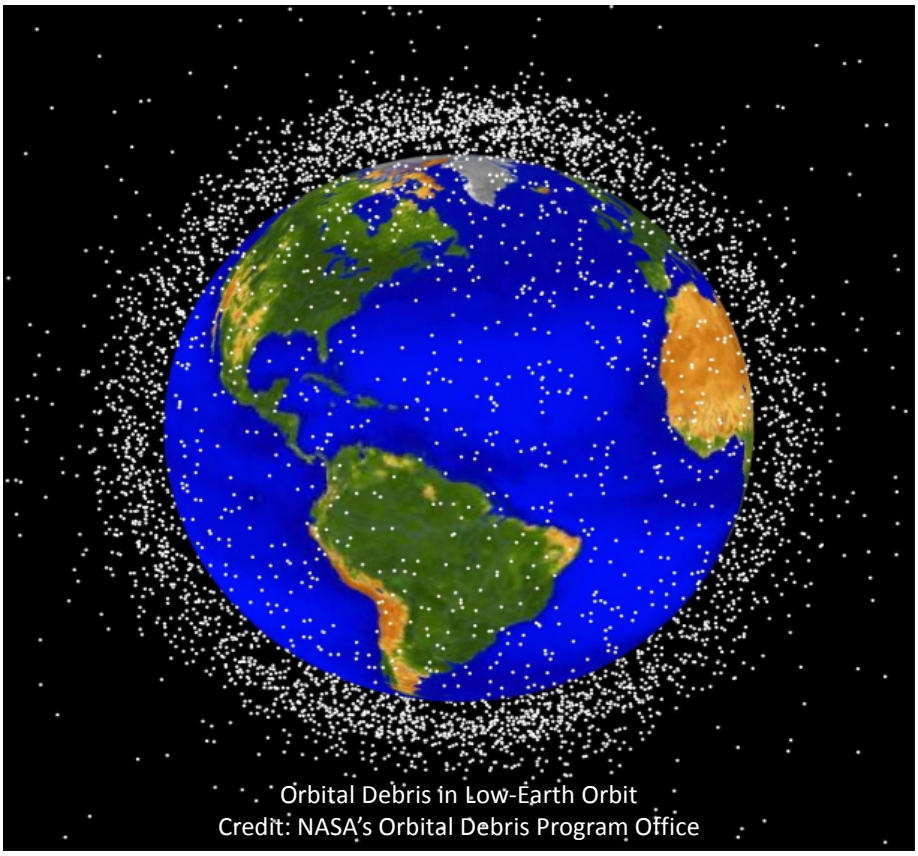
The Hubble Space Telescope's Wide Field Planetary Camera 2 was returned to Earth as part of the telescope's servicing mission in 2009 (STS-125). Attached to the camera was a large radiator (2.2 m by 0.8 m). The radiator had been in space since the camera was installed in 1993, and its large flat surface provided an excellent measure for determining impact rates for orbital debris at the telescope's

Payload Bay Door Impact NASA Photo

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 are 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.

NASA currently tracks almost 18,000 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, in particular 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.



Orbital Debris in Low-Earth Orbit
Credit: NASA's Orbital Debris Program Office

Until a solution can be found to cleaning up the debris (that is both technically feasible and economical), 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 newsletters (past and present) are available at *http://orbitaldebris.jsc.nasa.gov/newsletter/newsletter.html*.

A Changing Climate

The 7,000 mile cruise of Crystal Cruises' Crystal Serenity would have been unremarkable had the voyage not been through the Northwest Passage; a route through the Arctic Ocean connecting the northern Atlantic and Pacific Oceans. The traverse, made possible by globally warmer temperatures, was first accomplished by Norwegian explorer Roald Amundsen in 1906 (it took him three years, due to the thick ice pack).

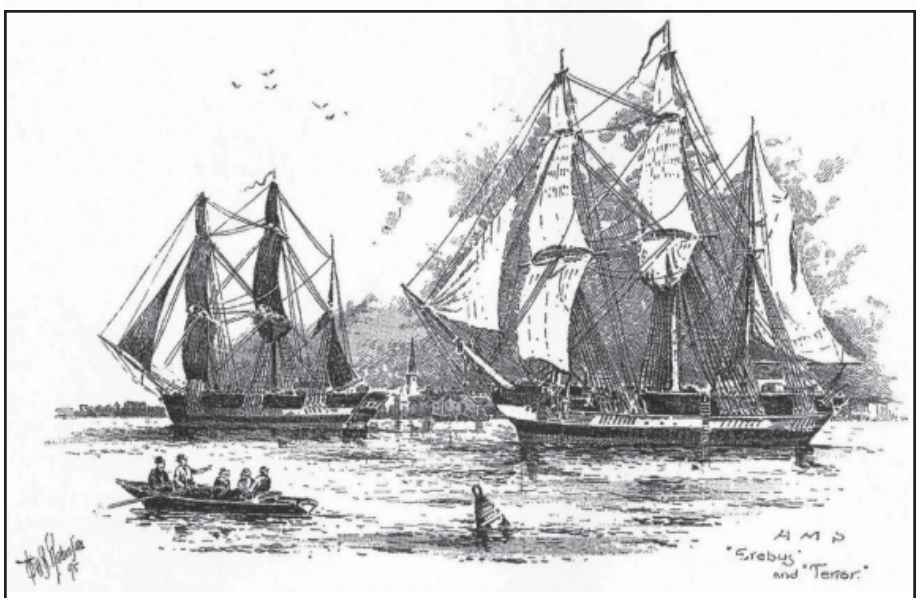
Crystal Serenity's 1,000 passengers and 600 crew spent a relatively uneventful 32 days on a route that was inaccessible to 19th century polar explorers.

By coincidence, as the cruise ship was completing its voyage, the Arctic Research Foundation announced that they had located the HMS Terror resting relatively intact on the sea floor off King William Island

in the Arctic. The ship was part of Sir John Franklin's 1845 polar expedition and attempt to navigate the Northwest Passage. The HM Terror, along with the HMS Erebus, were last seen by a whaler in Baffin Bay in late July waiting for the icepack to break. Sometime later, the two ships became locked in the ice in the straits northwest of Hudson Bay and were eventually abandoned. According to notes found in a stone cairn on the island, the surviving crew headed south over the ice after the death of Franklin in 1847. 19th century search parties failed to find the ships or any of 129 expedition members alive.

The HSM Erebus was found just two years ago resting on the sea bed.

Sea ice in the Arctic reaches its minimum coverage in September. Satellite observations since 1979 have shown a steady decline in the minimum, 13.3% per decade. The ice pack reached its lowest point in 2012 at 3.62 million square kilometers. While coverage increased in 2013, the decline continued the following year. This year (2016) the ice pack covered 4.72 million square kilometers, 65% of the area covered in 1979 and 60% of the peak coverage in 1996.



HMS Erebus and HMS Terror

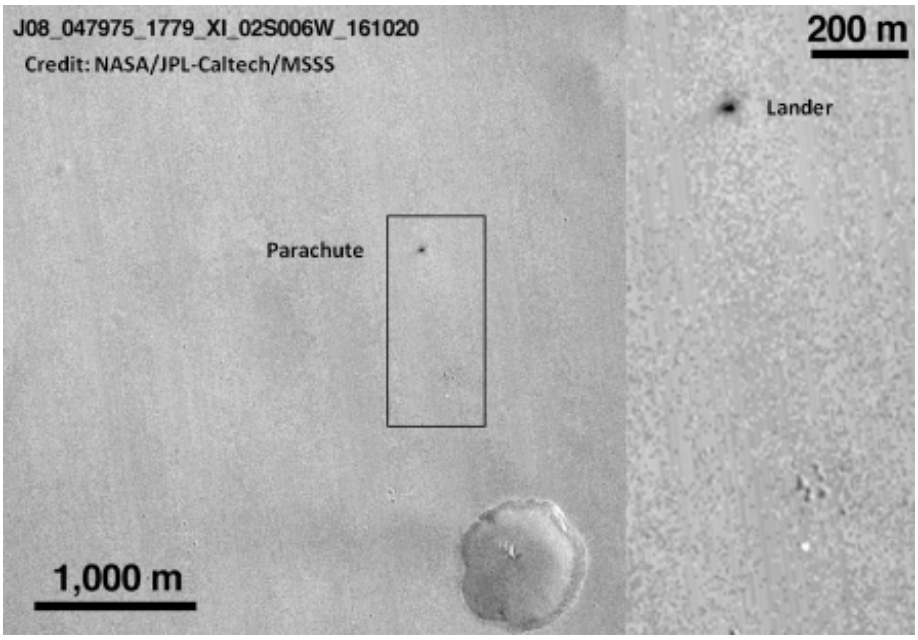
ExoMars and Schiaparelli

Part one of the European Space Agency's (ESA) two-part Mars exploration mission (ExoMars) achieved an important milestone with the insertion of the Trace Gas Orbiter (TGO) around Mars on October 19th. Once in its final trajectory, TGO will survey the Red Planet from an orbit 250 miles (400 km) in altitude, searching for sources of methane in the atmosphere. The orbiter will also map the Martian terrain and hunt for signs of subsurface water. The information collected by the orbiter will be used to select the target for a rover (the second part of the mission) set to launch in 2020.

TGO carried with it a demonstration lander to Mars, releasing it three days prior to arrival. The lander (Schiaparelli) entered the Martian atmosphere at an altitude of about 75 miles (121 km) and a speed of nearly 13,000 mph (21,000 km/h). Schiaparelli decelerated, first with its aeroshell (through ablation) and then by parachute. Once the lander's velocity slowed to 155 mph (250 km/h), the back half of the aeroshell along with the parachute was scheduled to be jettisoned. Three groups of hydrazine thrusters were then designed to bleed off the Schiaparelli's remaining velocity for a controlled landing on Meridiani Planum.

The descent did not go according to plan when, less than a minute before touchdown, TGO lost telemetry from the lander. While ESA is still analyzing the data, it appears that the rocket thrusters only operated for a few seconds (rather than the planned 30 seconds), allowing the lander to free fall from an altitude somewhere between 6,500 and 13,000 feet (2 and 4 km). With its tanks still full of fuel, the lander likely exploded on contact with the surface.

NASA's Mars Reconnaissance Orbiter (MRO) imaged Schiaparelli's landing site on October 20th, one day after the loss of communications from the lander. In comparing that image with one taken last May, two new features were apparent. The smaller spot is believed to be the parachute. The larger, irregular spot is likely the remains of the lander.

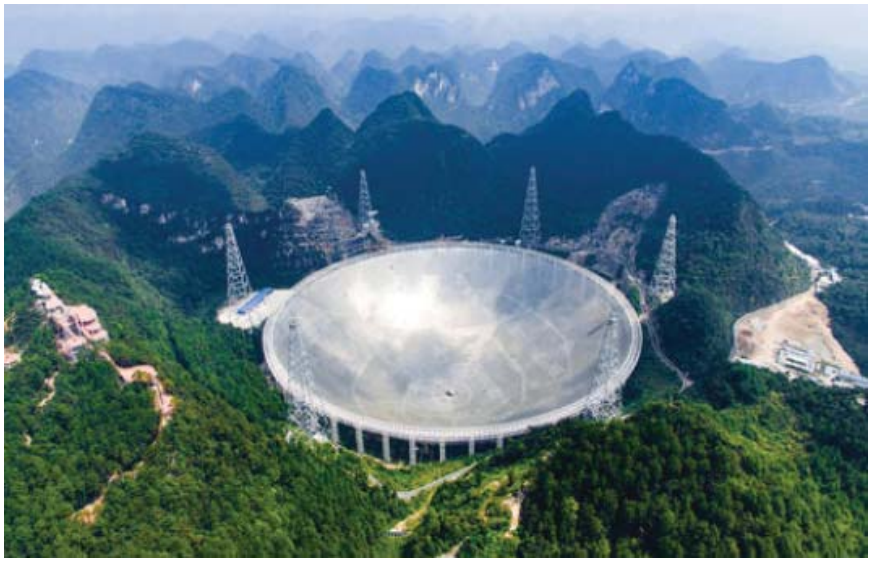


MRO is scheduled for another pass over the site in the next week and will use its higher-resolution HiRISE camera to image the wreckage.

Chinese Radio Telescope Operational

The world's largest (single dish) radio telescope, built in Guizhou Province, China, is now operational. At 1,640 feet across (500 meters), it is 650 feet larger than the next largest, Arecibo Observatory in Puerto Rico.

The radio telescope took five years, $180 million, and the relocation of 8,000 people to complete. The sensitivity of the telescope is expected to be twice that of the Arecibo dish.



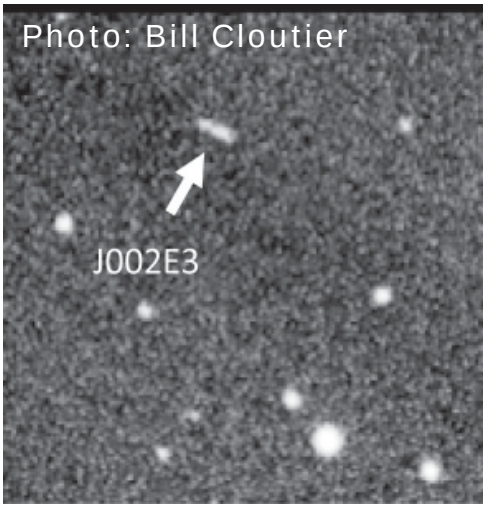
November History: Apollo 12

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).

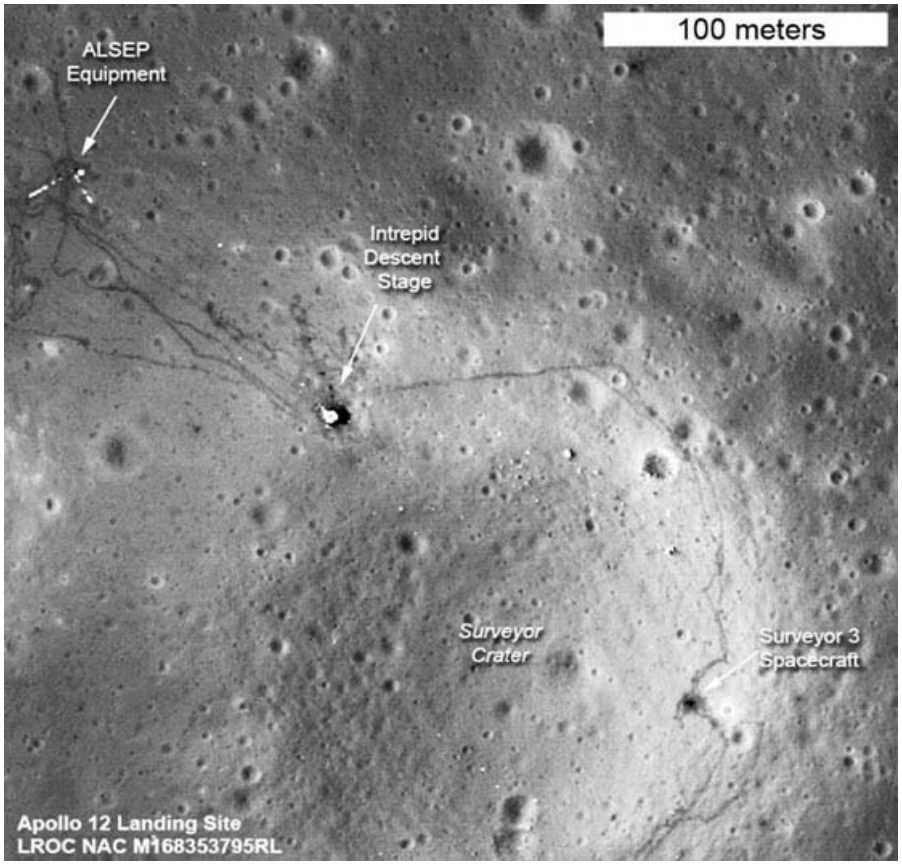
The Ocean of Storms was the designated landing site for Apollo 12, southeast of the large crater Lansberg. Mission Commander Pete Conrad made a pinpoint landing 535 feet from the Surveyor 3 spacecraft which had landed two years earlier. The diminutive Conrad joked as he stepped out onto the lunar surface 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.



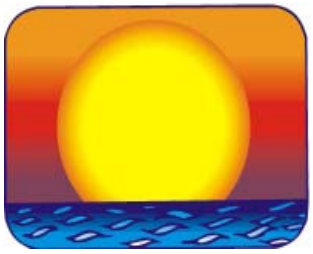
Credit: NASA/Goddard Space Flight Center/Arizona State

November Nights

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.



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
November 1st (EDT)	07:26	17:48
November 15th (EST)	06:43	16:33
November 30th	07:00	16:25

Astronomical and Historical Events

1st Distant flyby of Saturn's moons *Telesto* and *Polydeuces*
1st Apollo Asteroid 2006 KC near-Earth flyby (0.086 AU)
1st Kuiper Belt Object 120348 (2004 TY364) at Opposition (38.179 AU)
1st Kuiper Belt Object 2014 UM33 at Opposition (43.002 AU)
1st History: launch of the Wind spacecraft, designed to monitor the solar wind (1994)
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)
3rd Taurids Meteor Shower peak (associated with the comet Encke)
3rd Aten Asteroid 2012 XS111 near-Earth flyby (0.077 AU)
3rd Neptune Trojan 2006 RJ103 at Opposition (29.293 AU)
3rd Plutino 144897 (2004 UX10) at Opposition (38.226 AU)
3rd 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)
3rd History: launch of Sputnik 2 and a dog named Laika (1957)
4th Aten Asteroid 5381 Sekmet closest approach to Earth (0.337 AU)
4th Centaur Object 54598 Bienor at Opposition (14.491 AU)
4th Kuiper Belt Object 55637 (2002 UX25) at Opposition (39.758 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 Amor Asteroid 1580 Betulia closest approach to Earth (2.351 AU)
5th Kuiper Belt Object 84522 (2002 TC302) at Opposition (43.876 AU)
5th History: Chinese spacecraft Chang'e 1 enters orbit around Moon (2007)
6th End of Daylight Savings Time - set clocks back one hour at 2 a.m.
6th History: launch of Lunar Orbiter 2, Apollo landing site survey mission (1966)
6th Apollo Asteroid 468583 (2007 LS) near-Earth flyby (0.086 AU)
6th Apollo Asteroid 3360 Syrinx closest approach to Earth (1.091 AU)
7th First Quarter Moon
7th Apollo Asteroid 2002 UQ12 near-Earth flyby (0.050 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 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)

Astronomical and Historical Events (continued)

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)
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 Apollo Asteroid 2004 KB near-Earth flyby (0.026 AU)
10th Atira Asteroid 2012 VE46 closest approach to Earth (1.236 AU)
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 Distant flyby of Saturn's moon *Tethys* by the Cassini spacecraft
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 Second Saturday Stars - Open House at the McCarthy Observatory (7:00 pm)
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 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 Full Moon (Full Beaver or Full Frost Moon)
14th Moon at perigee (closest approach to Earth)
14th Flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
14th Atira Asteroid 2013 JX28 closest approach to Earth (0.722 AU)
14th Apollo Asteroid 2212 Hephaistos closest approach to Earth (1.129 AU)
14th Neptune Trojan 2007 VL305 at Opposition (27.221 AU)
14th Kuiper Belt Object 2012 VP113 at Opposition (82.501 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 Plutino 2003 UZ413 at Opposition (42.702 AU)
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)
15th Scheduled launch of a Russian Soyuz rocket from the Baikonur Cosmodrome, Kazakhstan, with the next expedition crew to the International Space Station
16th Flyby of Mars' larger moon Phobos by ESA's Mars Express spacecraft
16th Apollo Asteroid 326302 (1998 VN) near-Earth flyby (0.088 AU)
16th Apollo Asteroid 1865 Cerberus closest approach to Earth (0.339 AU)
16th Neptune Trojan 2011 WG157 at Opposition (29.834 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)

Astronomical and Historical Events (continued)

17th Leonids Meteor Shower peak (associated with the comet Tempel-Tuttle)
17th Kuiper Belt Object 2010 VK201 at Opposition (47.060 AU)
17th History: launch of Soyuz 20, a 90 day, long duration mission that carried a biological payload (tortoises). The tortoises returned to Earth in good health (1975)
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 433953 (1997 XR2) near-Earth flyby (0.048 AU)
18th Apollo Asteroid 11500 Tomaiyowit closest approach to Earth (0.209 AU)
18th Aten Asteroid 2340 Hathor closest approach to Earth (1.448 AU)
18th Plutino 84719 (2002 VR128) at Opposition (38.297 AU)
18th Kuiper Belt Object 90377 Sedna at Opposition (84.555 AU)
18th History: launch of the COBE spacecraft; observed diffuse cosmic background radiation (1989)
19th Moon occults Aldebaran
19th Distant flyby of Saturn's moons *Mimas*, *Daphnis*, *Methone* and *Pandora* by the Cassini spacecraft
19th Asteroid 3530 Hammel closest approach to Earth (1.262 AU) –named in honor of Dr. Heidi Beth Hammel, planetary scientist and member of the McCarthy Observatory's Board of Directors
19th Apollo Asteroid 4486 Mithra closest approach to Earth (1.645 AU)
19th Apollo Asteroid 1981 Midas closest approach to Earth (2.138 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 Last Quarter Moon
21st Aten Asteroid 2013 ND15 (Venus Trojan) closest approach to Earth (0.633 AU)
21st Apollo Asteroid 314082 Dryope closest approach to Earth (2.464 AU)
23rd Aten Asteroid 2012 UK171 near-Earth flyby (0.062 AU)
23rd Amor Asteroid 2005 TF near-Earth flyby (0.095 AU)
23rd History: launch of the European Space Agency's first satellite, Meteosat 1 (1977)
23rd History: launch of Tiros II weather satellite (1960)
25th History: Albert Einstein publishes his General Theory of Relativity (1915)
25th History: William Dawes discovers Saturn's C Ring (1850)
26th Kuiper Belt Object 386723 (2009 YE7) at Opposition (49.826 AU)
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 Moon at apogee (furthest distance from Earth)
27th Distant flyby of Saturn's moons *Epimetheus* and *Enceladus* by the Cassini spacecraft
27th Apollo Asteroid 4450 Pan closest approach to Earth (1.551 AU)
27th Kuiper Belt Object 145453 (2005 RR43) at Opposition (38.468 AU)
27th History: Soviet spacecraft Mars 2 arrives at Mars; lander crashes, becoming first human artifact to impact the surface of Mars (1971)
28th Mars Winter Solstice (northern hemisphere)
28th History: launch of Algeria's first satellite, Alsat 1 (2002)
28th History: launch of Mariner 4; first spacecraft to obtain and transmit close range images of Mars (1964)
29th New Moon

Astronomical and Historical Events (continued)

29th Flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
29th Apollo Asteroid 5143 Heracles closest approach to Earth (0.147 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)
30th Apollo Asteroid 369264 (2009 MS) near-Earth flyby (0.070 AU)
30th Amor Asteroid 3352 McAuliffe closest approach to Earth (0.519 AU)
30th Apollo Asteroid 10563 Izhdubar closest approach to Earth (1.060 AU)

Commonly Used Terms

- 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/Space Shuttle/Iridium Satellites

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

Solar Activity

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

Image Credits

Cover image: About 5,000 years ago, observers in the southern hemisphere may have seen a bright flash in the night sky. The light, originating from our neighbor galaxy, the Large Magellanic Cloud, was the fiery flash of a supernova that had already taken 160,000 years to reach Earth.

At the collapsed core of the supernova a spinning neutron star vents its rage. The filamentary remains are sheets of debris from the explosion, which will eventually be threaded into a new star system like our own—perhaps in another few billion years. For more information, go to *http://hubblesite.org/newscenter/archive/releases/2003/20/.*

Source: NASA and The Hubble Heritage Team (STScI/AURA); Y.-H. Chu (UIUC), S. Kulkarni (Caltech) and, R. Rothschild (UCSD)

Page 3 graphic: Home of Edmond Halley (1656-1742) in Oxford, England. Halley published his catalogue of stars of the southern hemisphere in 1678 at the age of 22 and his work on comets in 1687. He also published Isaac Newton's Principia (three laws of motion) at his own expense.

Halley was appointed Astronomer Royal in 1721. He is best known for successfully predicted the reappearance of the great comet in 1758 (now known as "Halley's Comet").

Second Saturday Stars poster: Marc Polansky

Second Saturday Stars

FREE EVENT

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

November 12th

7:00 - 9:00 pm

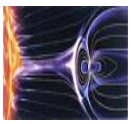
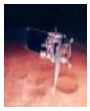
Starry Night

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

Map

November 2016

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Phases of the Moon  Nov 7 Nov 14  Nov 21 Nov 29		**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, Anerican 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)	**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)   2nd Saturday Stars Open House McCarthy Observatory
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) 	**14** Moon at Perigee (closest to Earth)   Launch of Apollo 12 Conrad, - 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)	**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) Discovery of Mars meteorites ¡AU 005 and SAU 008 (1999)
27 Moon at apogee (farthest from Earth) 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 Discovery of Y000593 Mars meteorite in Antarctica (2000)	**30** Sylicauga meteorite fall strikes Alabama woman (1954)		

Oct 2016

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Dec 2016

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