Galactic Observer

John J. McCarthy Observatory

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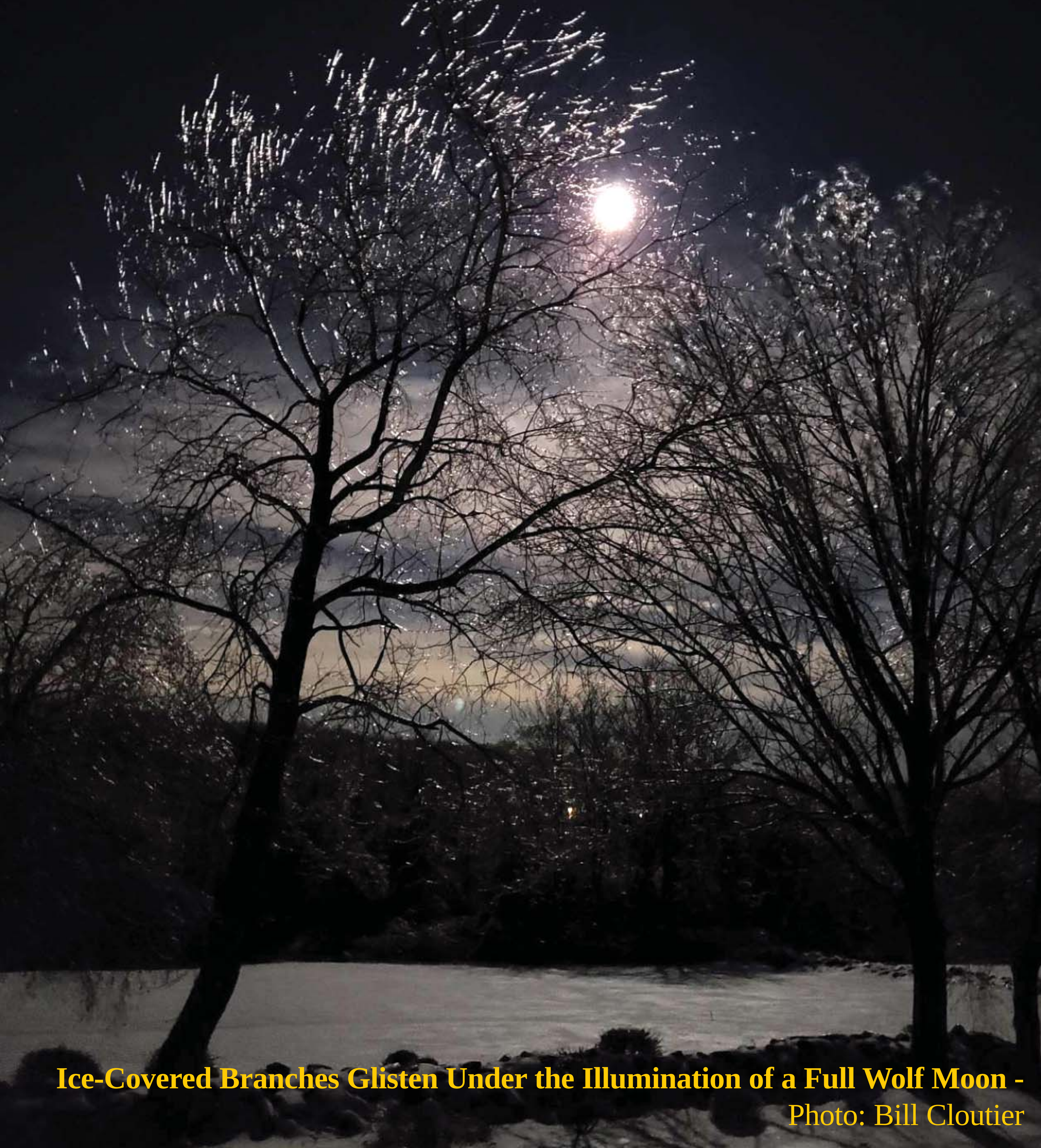
February 2019



Ice-Covered Branches Glisten Under the Illumination of a Full Wolf Moon -

Photo: Bill Cloutier

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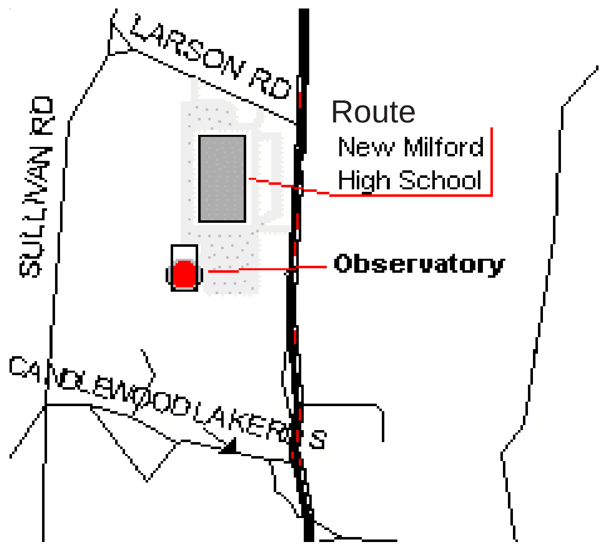
JJMO Staff

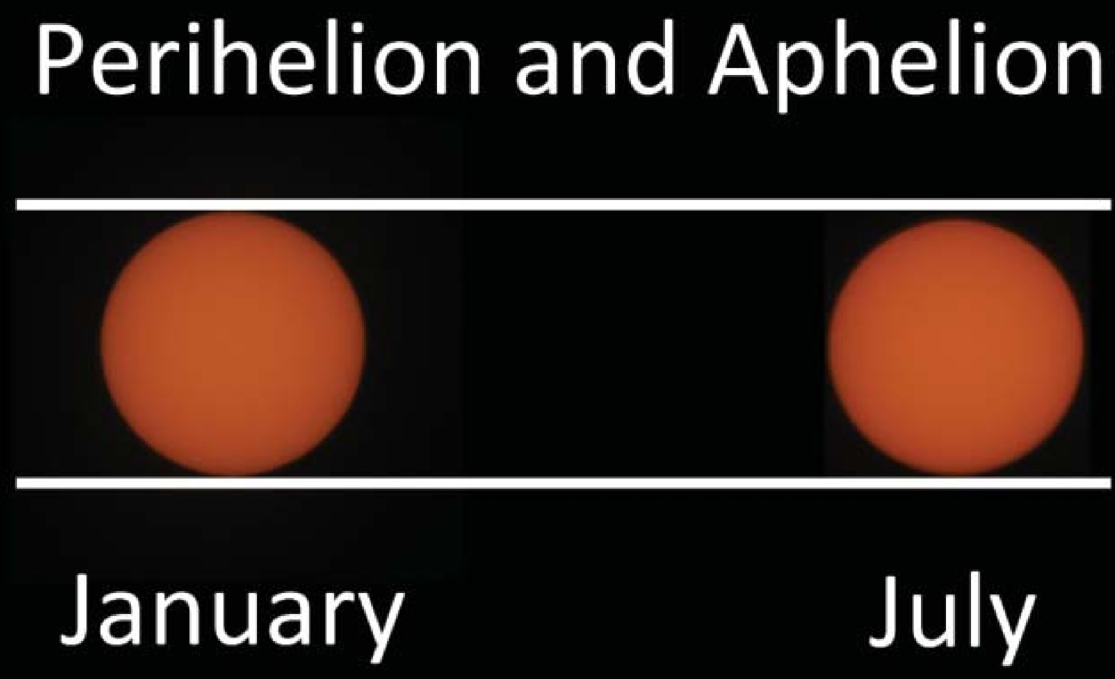
It is through their efforts that the McCarthy Observatory has established itself as a significant educational and recreational resource within the western Connecticut community.

Galactic Observer Editorial Committee



In This Issue

February Astronomy Calendar and Space Exploration Almanac



The Earth's orbit, like all planets that are bound to the Sun, is elliptical although its eccentricity (amount by which the orbit deviates from a perfect circle) is small. At its closest point to the Sun (perihelion), around January 3rd, the Earth is approximately 91.7 million miles (147 km) from the Sun while at the furthest, around July 4th, the Earth is approximately 94.8 million miles (152 km) from the Sun (a 3.1 million mile difference).

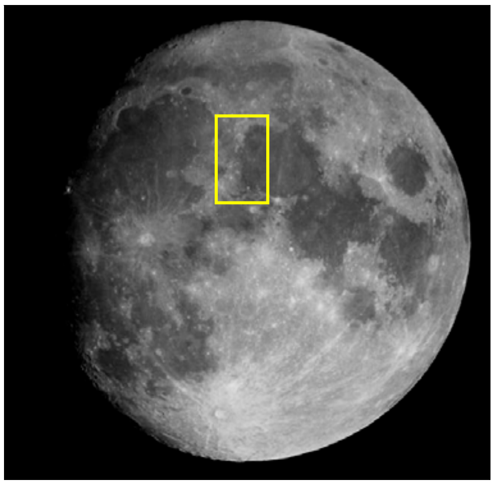
The images (above) were taken in early July 2017 and January 2018 with the same camera and identical settings. While the difference in the diameter of the Sun is small (with the 3.5% difference in the max/min distance), it is still noticeable.

The sunlight falling on the Earth is slightly more intense in January but with the northern hemisphere tilted away from the Sun and the Sun lower in the sky, the days are shorter and colder.

Photos: Bill Cloutier

Out the Window on Your Left"

It's been more than 45 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite;

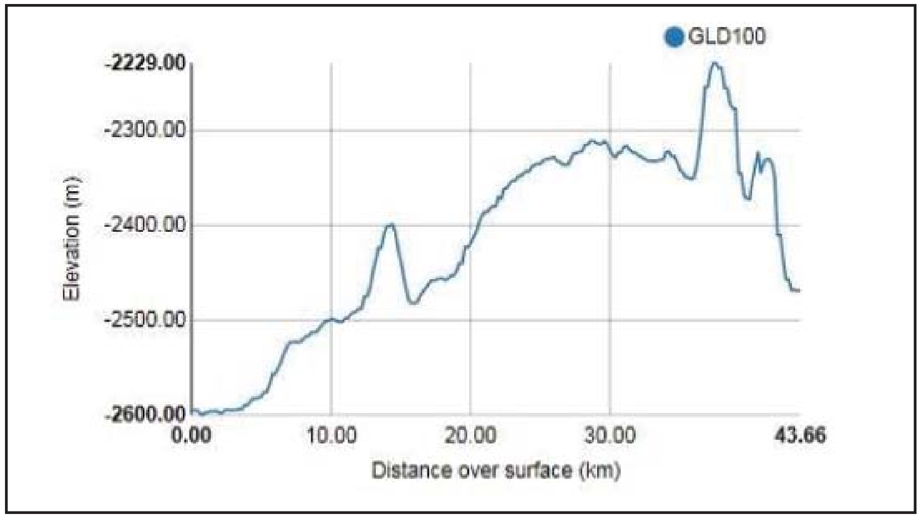


Lunar seas are actually expansive low-lying plains formed by ancient lava flows

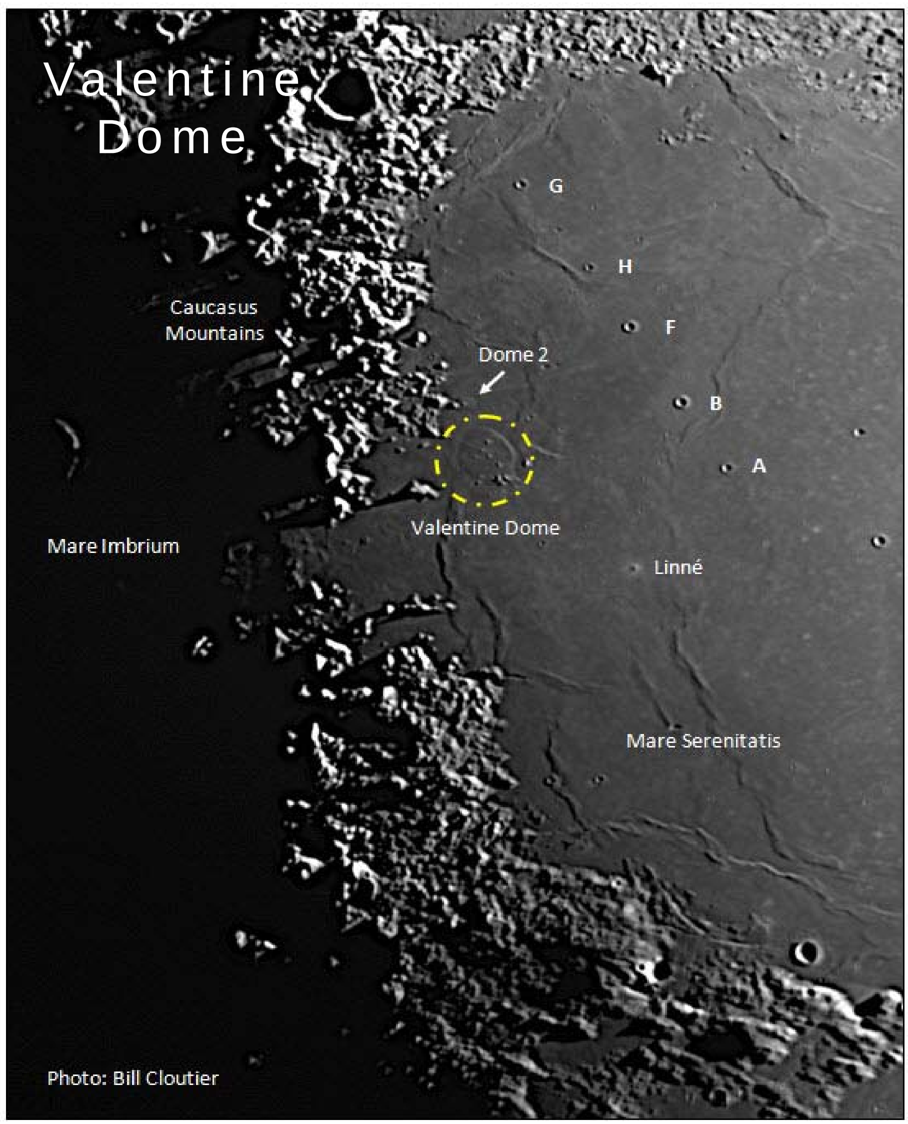
what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

A broad, low-profile lava dome is visible as the waxing Moon achieves first quarter phase on February 23rd and the Sun is low in the lunar sky. Valentine Dome is located along the northwestern shore of Mare Serenitatis (Sea of Serenity), along the Caucasus Mountains and just north of the breech into the Imbrium basin (30.9° latitude, 10.1° longitude). It is one of the largest domes visible on the lunar surface, measuring approximately 18.6 miles (30 km) across its heart-shaped surface.

Lava domes are volcanic protrusions created by an upwelling of magma. On average, the top of the Valentine dome rises 400 feet (122 meters) above the adjacent mare. The dome's north-south profile (shown below) was generated from data collected by the Lunar Reconnaissance Orbiter. Older peaks poke through the surface of the dome -- several are visible in the photo on the following page, as well as a faint rille (fissure) that traverses



LROC ACT-REACT-QuickMap http://target.lroc.asu.edu/q3/



the dome in an east-west direction. A second, much smaller dome, lies just to the north of Valentine.

For scale, crater Linné is 1.5 miles (2.4 km) across. Craters F and B are 3 miles (4.8 km) in diameter. Despite its small size, Linné brightens as the Moon waxes, becoming a bright white spot under the sunlight of a Full Moon.

Super Blood Wolf Moon

Lunar eclipse watchers in New England on the night of January 20/21 were hampered by the aftermath of a major snow and ice storm, frigid temperatures and arctic winds. In New Milford, skies cleared in time to view the partial eclipse phase, but a cloud layer moved into the area from the west around the time of totality that started at 11:41 pm EST. At first, the eclipsed Moon was visible through intermittent openings in the cloud deck, however; by mid-eclipse, the cloud deck had thickened. The temperature at mid-eclipse was 5°, with gusty winds and frozen toes.

During a total eclipse, the Earth blocks direct sunlight from illuminating the Moon. If the Earth did not have an atmosphere, the Moon would completely disappear within the Earth's shadow or umbra. With an atmosphere, sunlight is refracted or bent around the Earth, providing feeble illumination to an object within its shadow. The intensity of the scattered light varies by the amount of water vapor and particulate (dust, ash and other debris) in the atmosphere. This material can block, filter and/or scatter the sunlight as it's being refracted, thereby affecting the appearance of the Moon. French astronomer Andre Danjon created a five-point scale in the 1920s to evaluate the Moon's appearance during totality. An L0 value is so dark that little detail is visible. This can occur when a major volcanic eruption hurls dust and ash into the upper atmosphere that can effectively block refracted sunlight during an eclipse. On the other end of the scale, an L4 value is indicative of a relatively clear atmosphere. The L value for this observer in New Milford was between L2 and L3.

The Moon in the upper photo is not illuminated evenly, with the northern limb much brighter than the southern limb. Since the Moon's orbit is slightly inclined, its path through the Earth's shadow will vary, something traveling through the upper half and, at other times, traveling through the lower half. The Moon traveled though the upper half of the umbra during January's eclipse, so the Moon's southern limb was closer to the center of the shadow and therefore

Fully eclipsed supermoon captured around 12:15 AM EST on January 21, 2019. Photo: Bill Cloutier

West Coast observer, Conor Cloutier, reported fair weather conditions on Sunday evening with a temperature around 40°, but an eclipsed Moon darker in appearance (estimated between an L1 and L2) darker. The crimson color is the result of the Earth's atmosphere filtering out the shorter wavelength blue-colored light.

January's full moon occurred when the Moon was closest to the Earth in its elliptical orbit (the Moon's distance from the Earth can vary as much as 26,500 miles or 42,600 km). When this occurs, the Moon can appear up to 14% larger in the sky and 30% brighter, and is commonly referred to as a "supermoon."

To add to the excitement, several observers photographing the Moon at the start of totality managed to capture the flash from the impact of an object on the lunar surface, west of Mare Humorum (Sea of Moisture) at 11:41 p.m. EST. The Royal Observatory in Greenwich, England recorded a second flash two minutes later.

Update on Ultima Thule

Data from the New Horizons spacecraft's successful flyby of the Kuiper Belt Object (KBO) 2014 MU69 in the early morning of January 1, 2019 will be transmitted over the next 20 months. The down link was interrupted for almost a week in early January, due to the Sun's interference, as the spacecraft's position is currently on the other side of the Sun with respect to the Earth. Transmissions have now resumed.

What we know so far is that Ultima Thule (informal name) is a contact binary, red in color and likely created by a gentle collision of two bodies that accreted nearby when the solar system was in its embryonic stage. Consequently, Ultima Thule is providing scientists with their first look at a primordial object that they believe has not appreciably changed over the past 4 billion years.

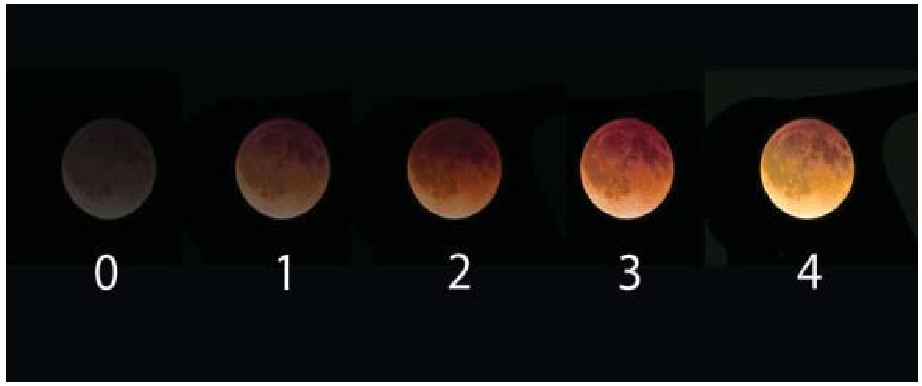
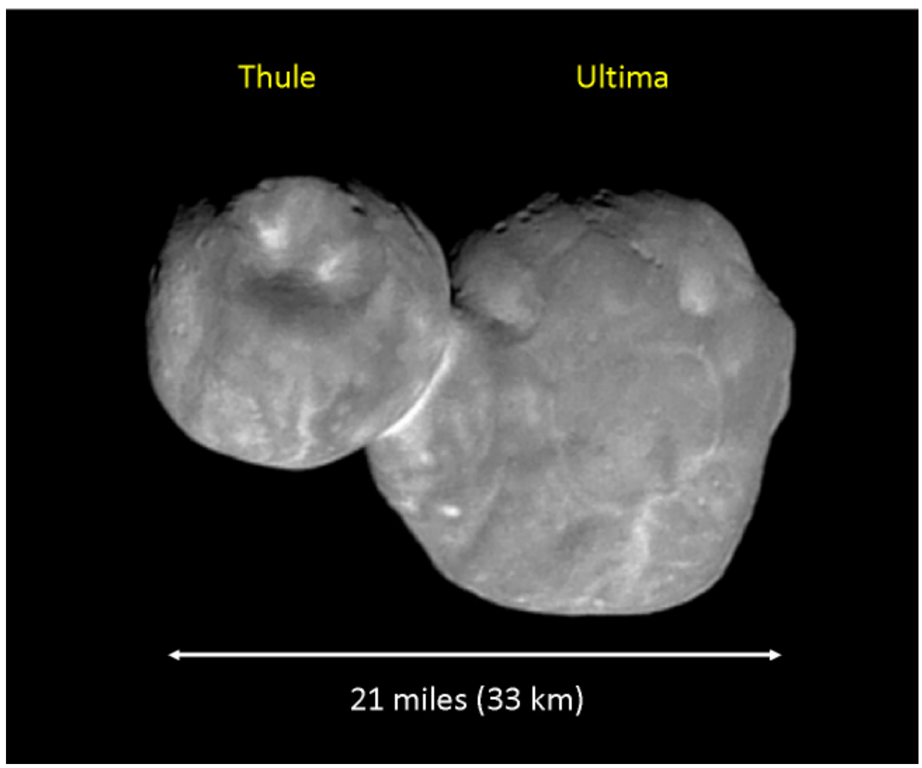


Image from the Griffith Observatory broadcast and the impact flash



Ultima Thule as captured by New Horizon's Multicolor Visible Imaging Camera component of the Ralph instrument just seven minutes before closest approach, at a distance of around 4,200 miles (6,700 km). Credit: NASA/JHUAPL/SwRI

The contact bnary has a rotation period of approximately 15 hours. The larger lobe, dubbed "Ultima" is about 2.6 times the volume of the smaller "Thule" lobe. Its total mass may be more difficult to determine without any moons, and the object's gravity's negligible effect on the spacecraft's trajectory. Scientists are waiting for information on the mineralogy to be downloaded, but comparisons with Pluto's moon Nix are already being made since it is of similar size.

The New Horizons spacecraft is heading out into the Kuiper Belt, collecting data on this remote region of our solar system. In March, the spacecraft's instruments will target another KBO, 2014 PN70, and the alternative flyby target to 2014 MU69. While the object will be too far away to be resolved, scientist are confident that they will be able to discern several physical properties, including shape, rotation rate, color, which they can then compare to Ultima Thule.

No decision has been announced as to New Horizons' next mission, but it is likely that preliminary discussions and proposals are already in the works. The spacecraft is currently 4.13 billion miles (6.64 billion km) from Earth and moving away from the Ultima Thule at more than 31,500 miles per hour (50,700 kph).

Perilous Times Ahead in the Galactic Neighborhood

It has been long known that the Andromeda Galaxy (M31) and the Milky Way Galaxy were heading for a collision in the distant future. The two spiral galaxies, currently separated by 2.54 million light years (almost 15 trillion miles or 24 trillion km) are currently moving towards each other at about 250,000 miles per hour (400,000 kph). However, it wasn't until recently that a team of astronomers led by Dr. Roeland van der Marel, were able to measure the lateral (or sideways) motion of the Andromeda Galaxy with the Hubble Space Telescope that we knew whether the meeting billions of years in the future would be a close miss, a glancing blow or head-on.

Marel's team's findings statistically favor a head-on meeting of the two galactic titans. Over billions of years following the initial contact, the two galaxies, and the black holes at their centers, will merge. They will lose their spiral characteristics and eventually form a single, massive elliptical galaxy.

But wait, it turns out there is another menace, lurking much closer, with the potential to transform the Milky Way in about 2.4 billion years, and possibly alter the circumstances of the Andromeda Galaxy encounter.

The EAGLE Project uses some of the world's largest super-computers to simulate the evolution of galaxies. Astrophysicists from the U.K. and Finland recently decided to use its capabilities to better understand the Milky Way's atypical attributes. The Milky Way, when compared to galaxies of similar size, has a less massive black hole at its center, a less massive halo (spherical, tenuous region surrounding the core), and stars within the halo that are metal poor. Researchers believe, from their work on the EAGLE Project, that spiral galaxies rely on mergers and acquisitions of smaller galaxies to reach full maturity, something that may not have occurred with the Milky Way in the past several billion years.

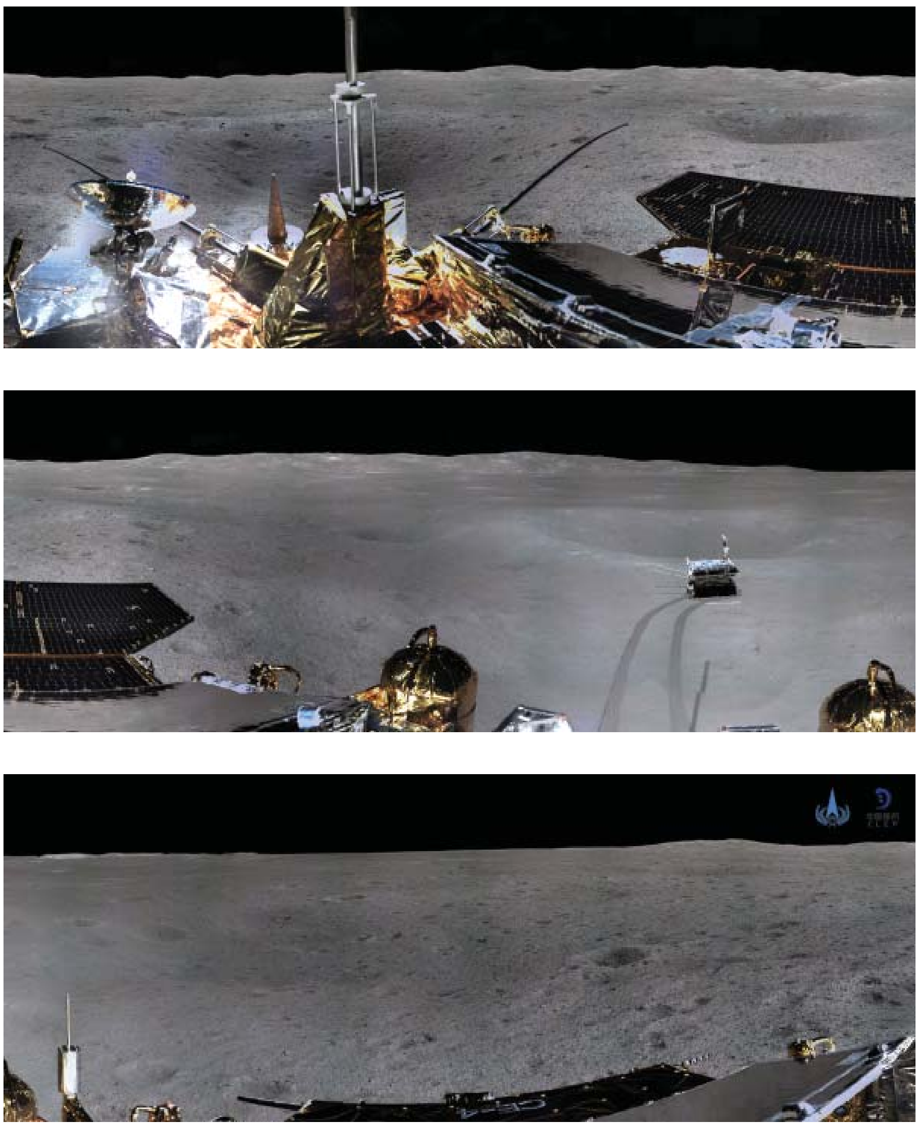
The hypothesis led the teams to look at the Large Magellanic Cloud (LMC), a dwarf galaxy just 163,000 light years away. A current satellite of the Milky Way, it arrived on location only 1.5 billion years ago. Astronomers had thought that the dwarf galaxy might eventually escape from the Milky Way's gravity with its current motion. However, it has been recently determined that the LMC has nearly twice the dark matter and, with the additional mass, is rapidly losing energy through dynamical friction. A collision with the Milky Way now

The Large Magellanic Cloud captured from ESO's La Silla Observatory. Credit: Zden?k Bardon/ESO appears inevitable, with a 68% confidence that it will occur in the next 2.4 billion years.

As described in the January 4th edition of *Monthly Notices of the Royal Astronomical Society*, a merger of the Milky Way and Large Magellanic Cloud could wake up the Milky Way's supermassive black hole, increasing its mass by up to 8 times (median value of 2.5), increase the mass of the Milky Way's halo and eject stars from the central disk into the halo, including (small probability), the Sun. The merger, based upon EAGLE Project simulations, would bring the Milky Way in line with its galactic counterparts. The metallicity of halo would also increase with the infusion of LMC stars.

A merger of the Milky Way and LMC will likely alter the position and velocity of the Milky Way's barycenter (center of mass). If this does occur, the collision with the Andromeda Galaxy, billions of years later, could be less head-on than currently predicted by the data collected by the Hubble Space Telescope. The timing of the encounter may also be delayed, with first contact occurring 1.5 billion years later.

China on the Far Side



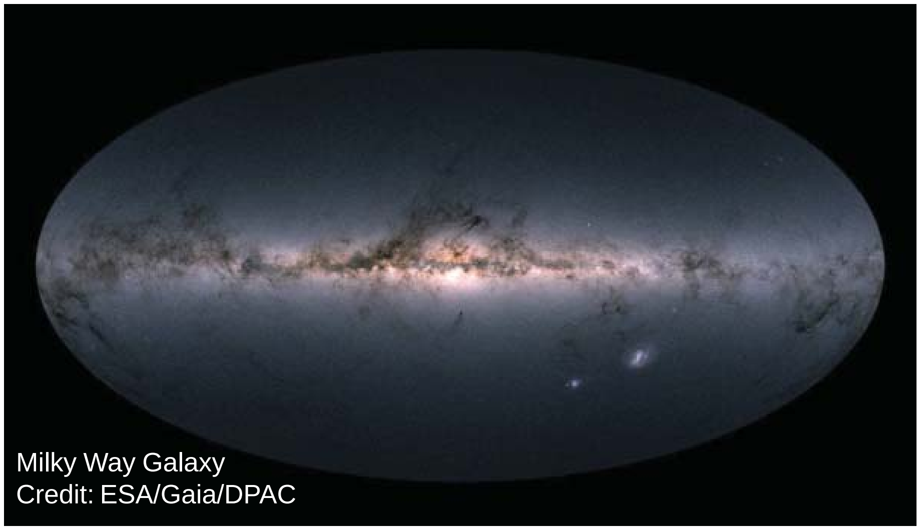
China's Chang'e 4 lander's first 360° panorama (segmented to facilitate viewing) captured in early January from its landing site in Von Kármán crater on the Moon's far side. Von Kármán crater is located within the South Pole-Aiken basin, the Moon's largest and oldest impact basin. The Yutu-2 rover can be seen in the distance in the middle frame. Credit: CNSA / CLEP

Galactic Cannibalism

Data from the European Space Agency's Gaia satellite, launched in 2013, is providing astronomers a glimpse into the Milky Way Galaxy's past, including evidence of an ancient collision with a large dwarf galaxy about 10 billion years ago. Gaia has charted the positions, motions, brightness and colors of nearly 1.7 billion stars within the Milky Way. This information is being used to construct the most detailed 3D map of our galaxy.

A number of studies, based upon the second data release last April (2018), point to an interloper that was cannibalized by the Milky Way in its formative years. A team led by Amina Helmi analyzed the angular momentum and orbit of 50,000 stars in the galaxy's halo. They identified 33,000 with similar amounts of angular momentum, but orbiting in the opposition direction that they should. A ground-based study of the chemical composition of 600 of those stars, and their characteristics pertaining to the increasing abundance of heavier elements with time, yielded an anomaly with respect to other stars in the galaxy. Helmi's team's work, combined with other studies led by astronomers such as Vasily Belokurov, who discovered stars moving counter to the galaxy's rotation, Helmer Koppelman, who found a cluster of stars orbiting in the opposite direction to most of the stars in halo, and Misha Haywood, who found fast-moving stars within the halo with atypical chemical abundances, can be reconciled with a head-on collision by a dwarf galaxy, roughly one quarter the mass of the Milky Way, when our galaxy was more embryonic in its structure or slightly larger than the Small Magellanic Cloud.

Helmi's team has named the dwarf galaxy "Gaia-Enceladus," a nod to the space observatory and a mythological giant believed to be responsible for earthquakes in the Mount Etna region. The collision puffed up the Milky Way's halo, and channeled new material into the galactic disk that triggered a new generation of star formation. While astronomers had long thought that galaxies, such as the Milky Way, grow through mergers, and have seen mergers in other parts of the universe, this study sheds new light on the early evolution of the Milky Way.

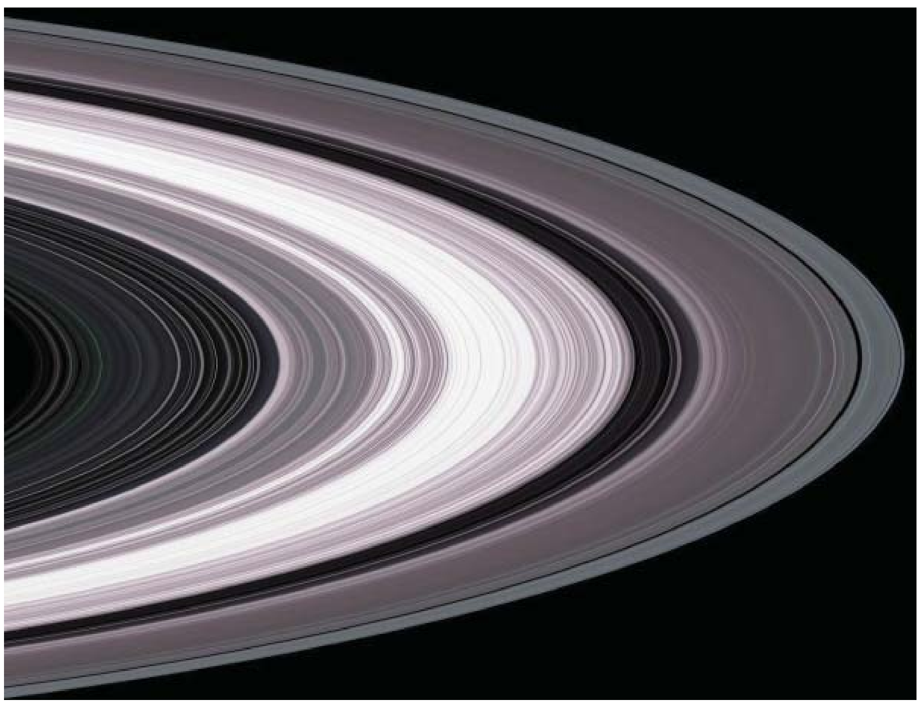

Milky Way Galaxy
Credit: ESA/Gaia/DPAC

Saturn's Ephemeral Rings

The grand rings of the planet Saturn are a relatively new addition, based upon data returned by the Cassini mission. The deduction was made possible by an accurate measurement of the mass of the rings, an accuracy that was not possible until the Cassini spacecraft flew between the planet and the rings (and could isolate the gravitational effects of one from the other). The passage of the spacecraft through the gap allowed scientists to measure the pull of gravity on the velocity of the spacecraft to a fraction of a millimeter per second that was then translated into the mass of the planet and the rings.

Researchers now believe that 1) the rings are comprised of mostly water ice, 2) the water ice is relatively young, having not been contaminated (and darkened) over time by interplanetary dust and debris, 3) the interplanetary dust impact flux on the rings is higher by almost a factor of 10, compared to the earlier estimates (the higher the flux – the younger the ring ice would have to be to be as bright as it is), 4) the total mass of the rings is approximately 34 sextillion pounds (15.4 sextillion kg) or about 40% of the mass of Saturn's inner moon Mimas, also believed to be comprised of water ice, 5) material from the rings migrates inward, eventually falling into the atmosphere of the planet, and 6) the rings will likely disappear in the next 300 million years.

Researchers concluded, as described in the January 17th issue of the journal *Science*, that the rings formed between 10 and 100 million years ago. This is counter

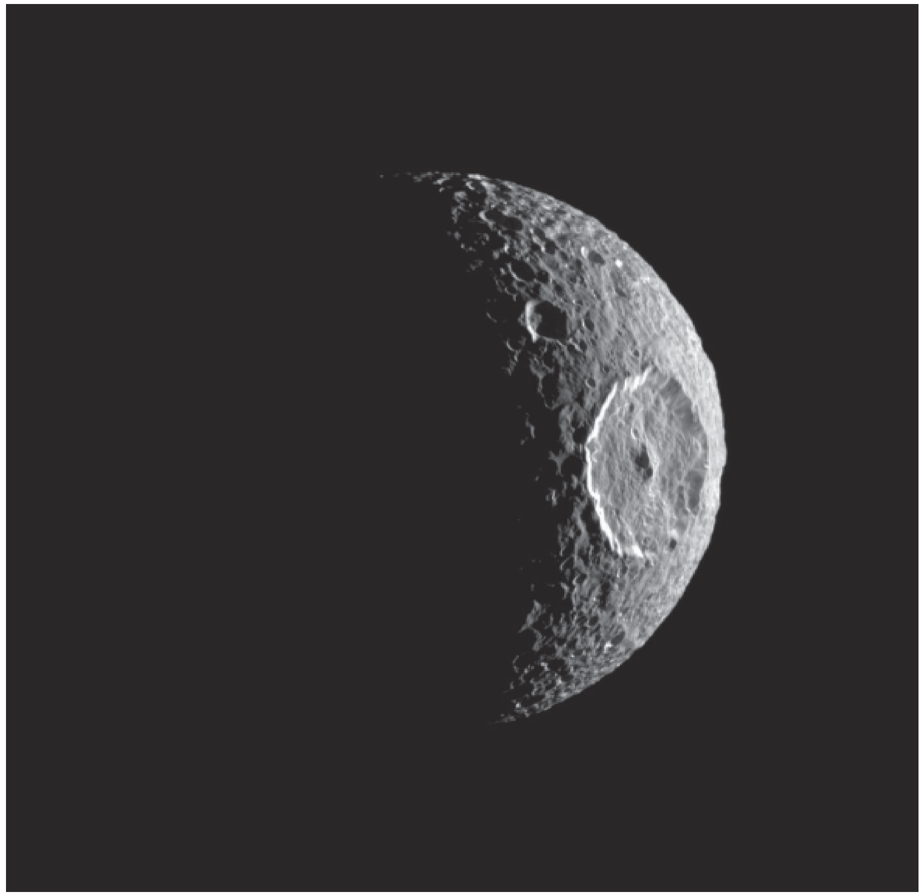

An optical depth profile of Saturn's rings where color is used to represent ring particle size. Source: NASA/JPL

to an interpretation put forward several years ago that the rings formed with the planet, approximately 4.5 billion years ago. However, the rings cannot be both bright and old, and the data provided by Cassini's instruments on ring composition (mostly ice with about 1% dust), the ring rain rate (loss to the planet's atmosphere), current mass, and general impermanence appears to provide a convincing case for the rings being a relative recent and transient feature.

How the rings came to be remains a mystery, although several processes could have been involved to create a low-mass ring system. The icy debris that comprise the rings could have come from a comet or Kuiper Belt Object that strayed too close and was captured and broken apart by Saturn's tidal forces, or possibly, through a collision or destruction of small icy moons. If the rings had been more massive, it would have supported a much older age, when there was more material available in the solar system.

Cassini's transits of the ring gap also provided scientists valuable information on the planet's atmosphere. At the equator, the outer layers of Saturn's atmosphere rotate faster than the inner layers (much like the behavior of Jupiter's atmosphere). It was known that, at some level, the atmospheric layers start to rotate in synchrony. Data from the Cassini spacecraft indicated that layer synchrony does not start until at least 5,600 miles (9,000 km) below the top cloud deck, three times deeper than on Jupiter.

The gravity measurements allowed researchers to determine the mass of Saturn's core. The core of the planet is now estimated at between 15 and 18 Earth masses.



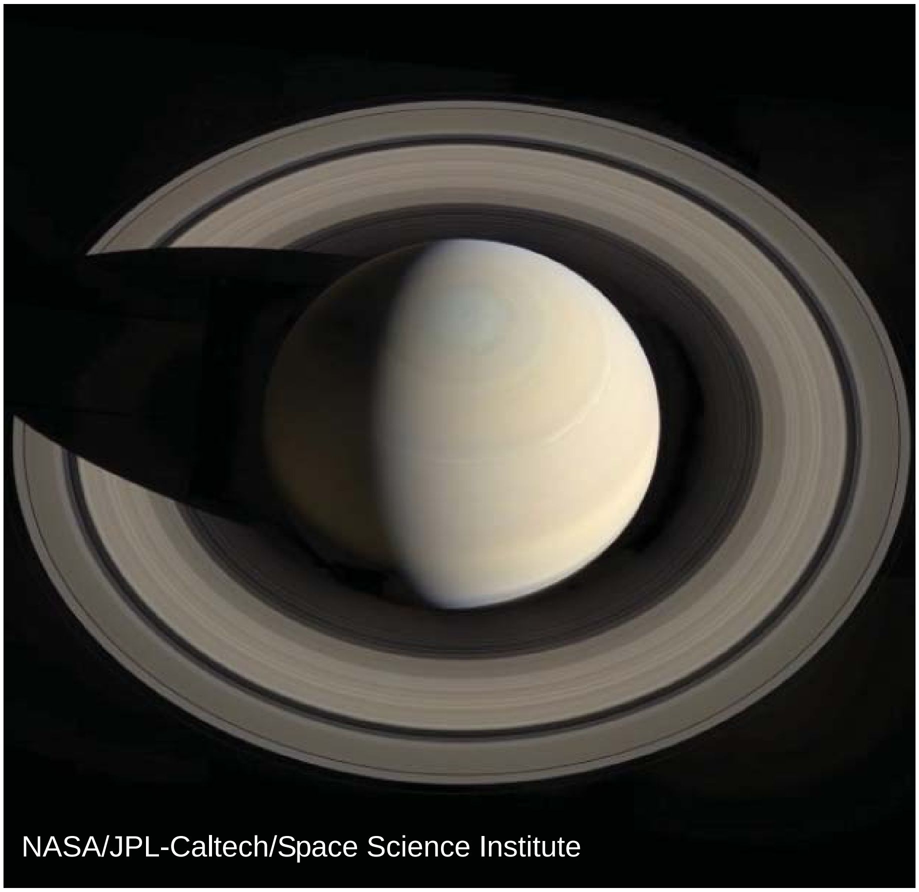
Mimas, Saturn's closest major moon. With a mean diameter of 246 miles (198 km), Mimas is believed to consist almost entirely of water ice and is responsible for clearing material from the gap (Cassini Division) between the A and B rings. Credit: NASA/JPL/Space Science Institute

The Cassini spacecraft spent thirteen years in orbit around Saturn, exploring its moons and ring system. The mission ended in September 2017, when, low on fuel, the spacecraft was placed on a trajectory that took it into the planet's atmosphere. The destruction of the spacecraft eliminated the potential for it contaminating Saturn's ocean moons.

A Day on Saturn

Cassini's Grand Finale provided an answer to a long-standing question – how long is Saturn's day? In many instances a planet's magnetic field, as it rotates around the axis, can be used to determine the period of rotation, particularly for those bodies with no permanent surface markings. However, Saturn's magnetic field is almost perfectly aligned with the axis of rotation, unlike Jupiter's or Earth's magnetic fields which are offset.

Christopher Mankovich, at UC Santa Cruz, looked to wave patterns in the rings for the answer. As predicted by Mark Marley in 1990, co-author of the article appearing in the *Astrophysical Journal*, the particles in the rings respond to variations in the planet's gravitation field, arising from vibration within the planet. Mankovich's tracking of the ring waves, and their correlation to the planet's internal structure, yielded the length of a day at 10:33:38 (hours: minutes: seconds), several minutes faster than derived from Voyager's observations in 1981.



NASA/JPL-Caltech/Space Science Institute

rock layers. Byrne postulates that, if the rock is too hard, the absence of geologic activity could impede the development of biological activity.

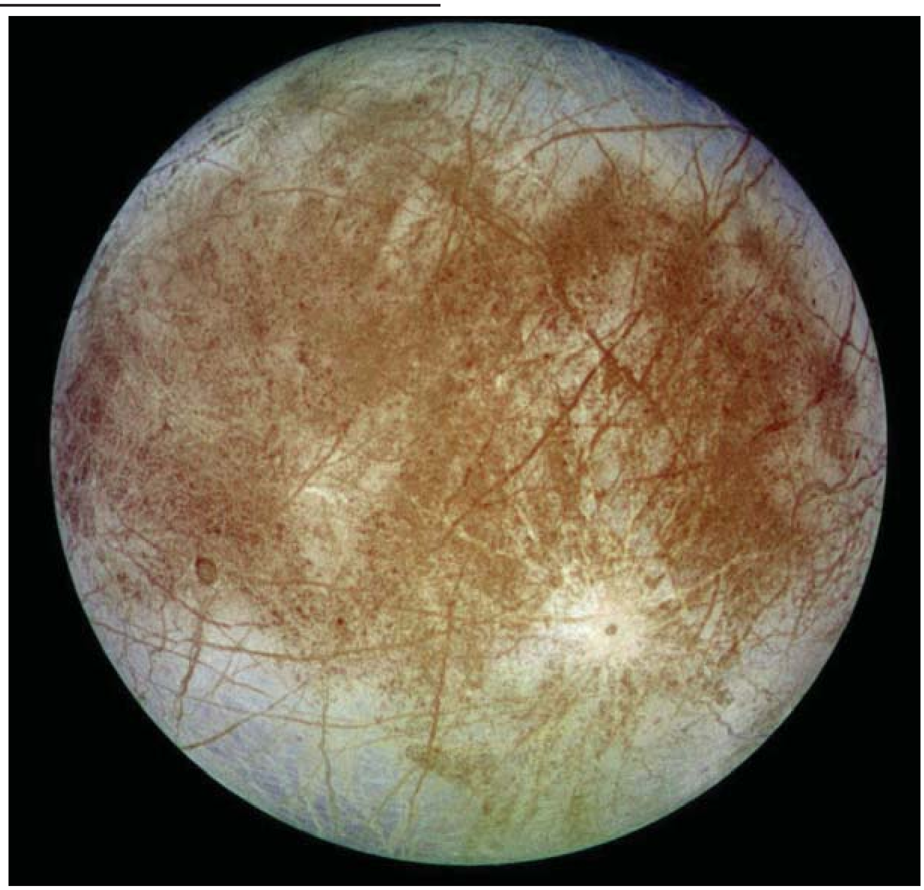
Byrne's team looked at four ocean worlds: Europa and Ganymede (Jupiter's moons) and Enceladus and Titan (Saturn's moons), calculating the strength of the rock on each body and the force required to pull the rock apart (creating faults) or push the rock together (creating thrust faults). The calculations considered the thickness of the rock layer, weight of water and ice on top of the rock layer, and gravitation forces at the depth where seawater and rock meet.

The initial results (Byrne's research hasn't been published, but he expects a response from the scientific community) are not encouraging. The rock strength

Rock Strength and Implications for Life on Ocean Worlds

NASA has been searching the solar system for signs of water, identifying a number of candidates in the solar system (all moons, with the exception of Mars) in the quest for life beyond Earth. However, recent work by Paul Byrne, a planetary geologist at North Carolina State University, has introduced a new variable when evaluating the habitability of the ocean worlds, such as Europa.

If the sea floor of the Earth is representative of other ocean worlds, the interaction of rock and seawater provides an energy source for primitive organisms. On Earth, the ocean floor is either porous or easily fractured to allow seawater to be heated and chemically react with the minerals in the subsurface



Approximate natural color of Jupiter's moon Europa.
NASA/JPL-Caltech/DLR

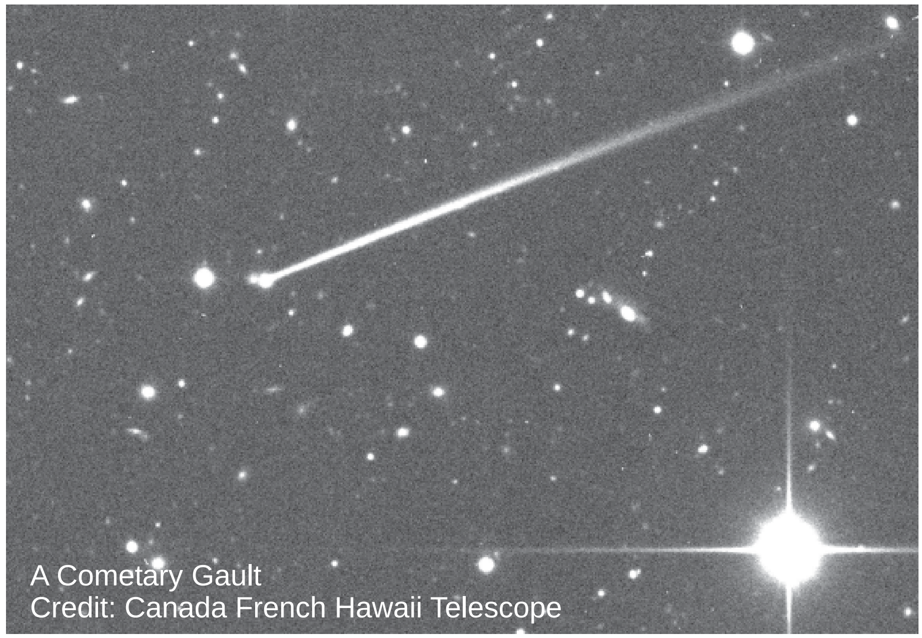
calculated for Titan and Ganymede is so high as to preclude fracturing (based upon the sheer weight of the overlying water and ice). The numbers for Europa are equally discouraging (just not as high as the larger moons).

Enceladus' rock strength numbers are much lower, since the moon is physically much smaller than the other three moons. The diminutive moon's core is also believed to be porous, with evidence of hydrothermal activity on the sea floor that drives the icy geysers erupting from the south polar region. Byrne's analysis raises an interesting question. If his arguments are persuasive and modeling valid, is NASA jetting off to the wrong moon with the Europa Clipper mission?

Rumble in the Asteroid Belt

Space is largely portrayed as an empty void, with little or no interaction between the residents of our solar system. This applies to the asteroid belt, notwithstanding Hollywood's depiction of the region as a swarm of hazardous looking rocks threatening would-be space travelers.

Asteroid 6478 Gault was an innocuous rock, approximately 2.3 miles (3.7 km) in size and located on the inner region of the asteroid belt. It is believed to be a member of the Phocaea family of asteroids (named after the largest member, 25 Phocaea, which is almost 47 miles or 75 km across). Gault was discovered in 1988 by Gene and Carolyn Shoemaker and named after Donald Gault, an expert in impact cratering. It orbits the Sun with a period of 3.5 years, at a distance that ranges from 1.86 to 2.75 AU (1 AU is the average distance of the Earth from the Sun or approximately 93 million miles or 150 million km).



A Cometary Gault
Credit: Canada French Hawaii Telescope

On January 5th, images captured by an ATLAS telescope show Gault with a tail. ATLAS (Asteroid Terrestrial-Impact Last Alert System) is a program developed by University of Hawaii astronomers to detect potentially hazardous asteroids and operates survey telescopes on Haleakala and Mauna Loa. records search found a similar tail in images taken as far back as early December.

Gault now has a cometary appearance with a tail estimated at 250,000 miles (400,000 km) in length. It is surmised that the tail may be debris from a collision with another object, likely sometime in November. Continued observation may provide clues to its sudden transformation.

Spotlight on the McCarthy Observatory Meteorite Collection

In the summer of 2018, the Observatory greatly expanded its meteorite teaching collection with the addition of a diverse and comprehensive set of meteoritic specimens from a reputable collector looking to convey his collection to someone who would maintain its integrity and capitalize on its intrinsic educational value. The collection includes whole stones, slices and fragments, numbering more than 200, from historic and scientific-significant falls and meteorite finds dating back to 1492. From time to time, we will highlight one or more of the specimens from the collection in this newsletter.

The McCarthy Observatory's meteoritic sample of Chelyabinsk is a whole stone weighing 1.15 grams. Its fusion crust, created as the air heated by the meteor's passage through the Earth's atmosphere and melting the outer layer of the stone, completely covers the stone.

The genesis of the Chelyabinsk superbolide (extreme bright meteor) was a 12,000 ton and 62-foot-wide (20 meter) meteoroid that entered the Earth's atmosphere at a shallow angle at approximately 42,600 mph (68,600 kph) early in the morning on February 15, 2013. Its entry was first detected at an altitude of 59 miles (95 km). As the meteor dropped in altitude, cloaked in superheated air, it started to fragment, releasing kinetic energy mea-

McCarthy Observatory's Chelyabinsk Meteorite. Image: Don Merchant

sured in kilotons. At roughly 19 miles (31 km) in altitude, the meteor exploded, breaking into boulder-size fragments, and releasing over 100 kilotons of energy. At this point in its flight, the super bolide was brighter than the Sun. The resulting shock wave was strong enough to knock people on the ground off their feet. In the city of Chelyabinsk, in west-central Russia, window glass was broken in 3,613 buildings and approximately 1,600 minor injuries were reported.

As the individual fragments decelerate, they go dark (stop emitting light). The entire event lasted just 16.7 seconds (from the first sighting of the super bolide to the final sighting of the last fragment). In that time, the meteor traveled 169 miles (272 km). It was the largest airburst since the Tunguska event in Siberia in 1908.

Less than one percent of the initial mass survived its atmospheric trek to fall as meteorites (estimated at 4 to 6 tons), with the remaining material evaporated or converted to dust. One of the largest fragments fell through the ice-covered Lake Chebarkul, creating a 25-foot (7 meter) diameter hole.

The Chelyabinsk meteorites are classified as LL chondrites (a low iron and low metal group of stony meteorites). Its low compressive strength may have contributed to its fragmentation and almost total disintegration. The cosmic ray exposure age of the Chelyabinsk meteoroid was measured at 1.2 million years (the time from when the meteoroid broke off from its parent body and was exposed to high-energy cosmic radiation to its fall to Earth).

Bennu

The OSIRIS-REx spacecraft successfully entered orbit around the 1,640-foot-wide (500 meter) asteroid Benne on December 31st, the smallest object to be orbited. The orbit carries the spacecraft to within one mile (1.6 km) of the stony surface.

The spacecraft's PolyCam, an 8-inch (20 cm) telescope, is being used to survey the asteroid's surface and map potential sampling sites. The mapping process is expected to last more than a year, at which time the spacecraft will briefly touch down to collect a sample. The sampling process uses nitrogen gas to disrupt the surface material for collection by the sampling arm's sampler head. There is enough gas for three attempts. If successful, up to 70 ounces (2,000 gms) will be placed in the sample return capsule for return to Earth in September 2023.

OSIRIS-Rex's 26-month stay around Bennu provides scientists with the opportunity to study a near-Earth and potentially hazardous asteroid. Bennu's orbitwell known for the immediate future, is influenced by other bodies in the solar system, including the Earth and Moon during close encounters (in 2060 Bennu will pass by the Earth at a distance only twice as far as the Moon is from the Earth). The gravity of these more massive objects slightly alters the trajectory of the asteroid and changes the parameters for future encounters with Earth.

Asteroid mosaic composed of 12 PolyCam images from a distance of 15 miles (24 km). Credit: NASA/Goddard/University of Arizona.

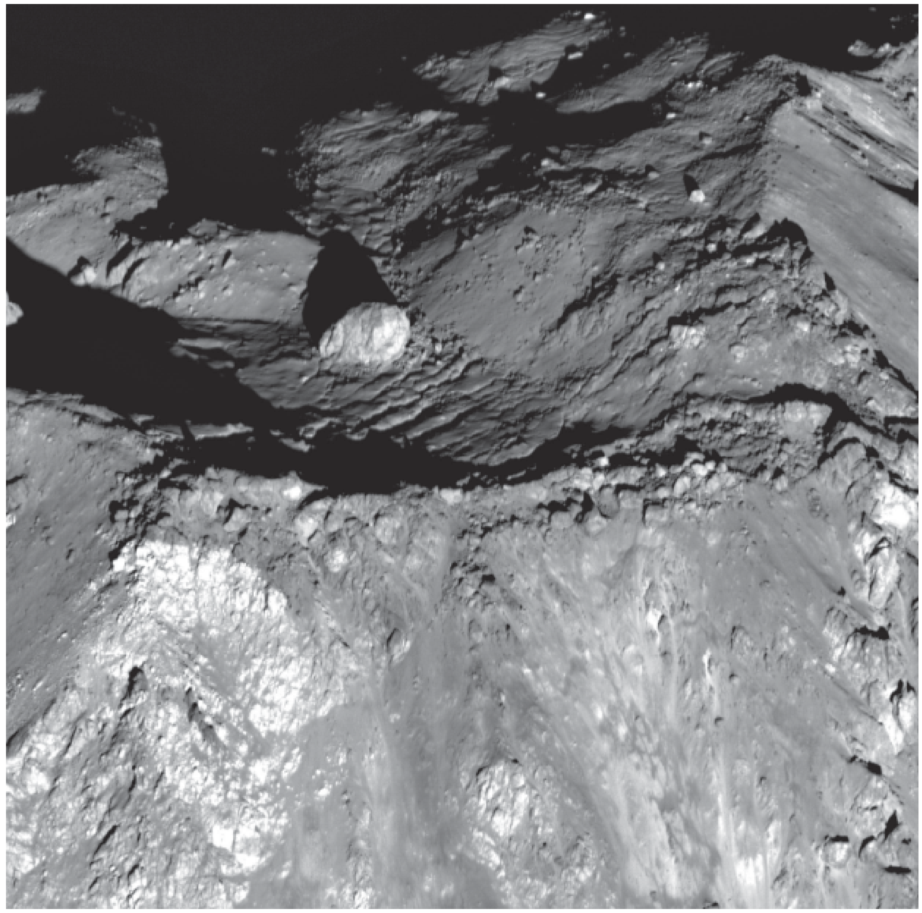
Asteroids are affected by another, more subtle, phenomenon, called the Yarkovsky effect and named after a Polish civil engineer who first described it in 1901. Ivan Yarkovsky surmised that the uneven heating of an asteroid by the Sun could provide a tiny thrust to the object (as the warmer side rotates out of the sunlight and radiates heat to space), which, over time, would move it closer or further away from the Sun, depending upon the asteroid's rotation. This effect, while small (astronomers have measured the shift for Bennu at 0.18 miles or 284 meters towards the Sun since 1999 due to the effect), increases the difficulty of projecting orbits over hundreds or thousands of years. Having the OSIRIS-REx spacecraft on station for more than two years will allow researcher to measure the changes in the asteroid's orbit over time and measure the heat radiating off the asteroid. What scientists do not know is how boulders and craters on the asteroid's surface affect the way the asteroid cools. NASA predicts that the accuracy of its projections for Bennu will increase by a factor of 60, as a result of the mission.

Cratering Rate Changes on the Moon and the Implications for Earth

Researchers have used data collected by NASA's Lunar Reconnaissance Orbiter (LRO) to create a timeline of major impacts on the Moon over the past billion years. As reported in the journal *Science*, an increase was found (by a factor of 2 to 3 times) starting around 290 million years ago, as compared to the prior 700 million years.

The analys used data collected by the LRO's thermal radiometer, called Diviner. Heat radiated by the lunar surface during the long night is correlated to the number of large rocks (which retain heat) excavated by impacts, as compared to the amount of finely pulverized, and cooler regolith. Using the rate at which the rocks are broken down by micrometeorites over tens to millions of years, a crater's age can be determined. The team, led by planetary scientist Rebecca Ghent, painstakingly catalogued lunar craters created in the last billion years.

The analysis has implications for Earth and life on Earth. With its larger mass, about 20 asteroids hit the Earth for every one that hits the Moon. The absence of large, older craters on Earth had been attributed to erosion and other destructive processes. Now, with the Moon providing a geologic record, it may be that a lower impact rate is to blame for the absence of ancient craters.



Tycho Crater's 108 million year old central peak with large boulder (400 feet or 120 meters across)
Credit: NASA Goddard/Arizona State University

Superovas

A supernova is an explosion produced when a massive star exhausts its fuel and collapses. These collapsing stars are typically red supergiants at least 8 times more massive than our Sun. If the original star is less than 20 solar masses, the supernova leaves behind a neutron star, approximately 10 to 17 kilometers (6-10 miles) across, a teaspoon of which weighs 200-400 million tons (more massive stars can collapse into black holes). One of the more famous remnants of a supernova is the Crab Nebula, visible with a moderately sized telescope in the winter sky in the constellation Taurus.

Many of the supernovas that occur in the Milky Way Galaxy are obscured from our view by gas and dust. On average, one supernova is detected in our galaxy every century (undetected supernovas may occur every 25 to 50 years, based upon our observations of other galaxies). Supernovas can become so bright that they overwhelm their host galaxies for weeks. In the last thousand years, there were four supernovas in the Milky Way that were well documented: a star in the constellation Lupus in the year 1006, one in the constellation Taurus in 1054 (described by Chinese astronomers), one in Cassiopeia in 1572 (observed by Tycho Brahe), and another in Ophiuchus in 1604 (studied by Johannes Kepler).

One of the most scrutinized supernovas occurred within the Large Magellanic Cloud, a satellite galaxy to the Milky Way. In February 1987, a star exploded near the Tarantula nebula some 169,000 light years away. It was the first time that astronomers haddetailed observations, not only of the supernova, but also of the star before it exploded. The most unusual feature of Super-

Canaveral, Florida, the first

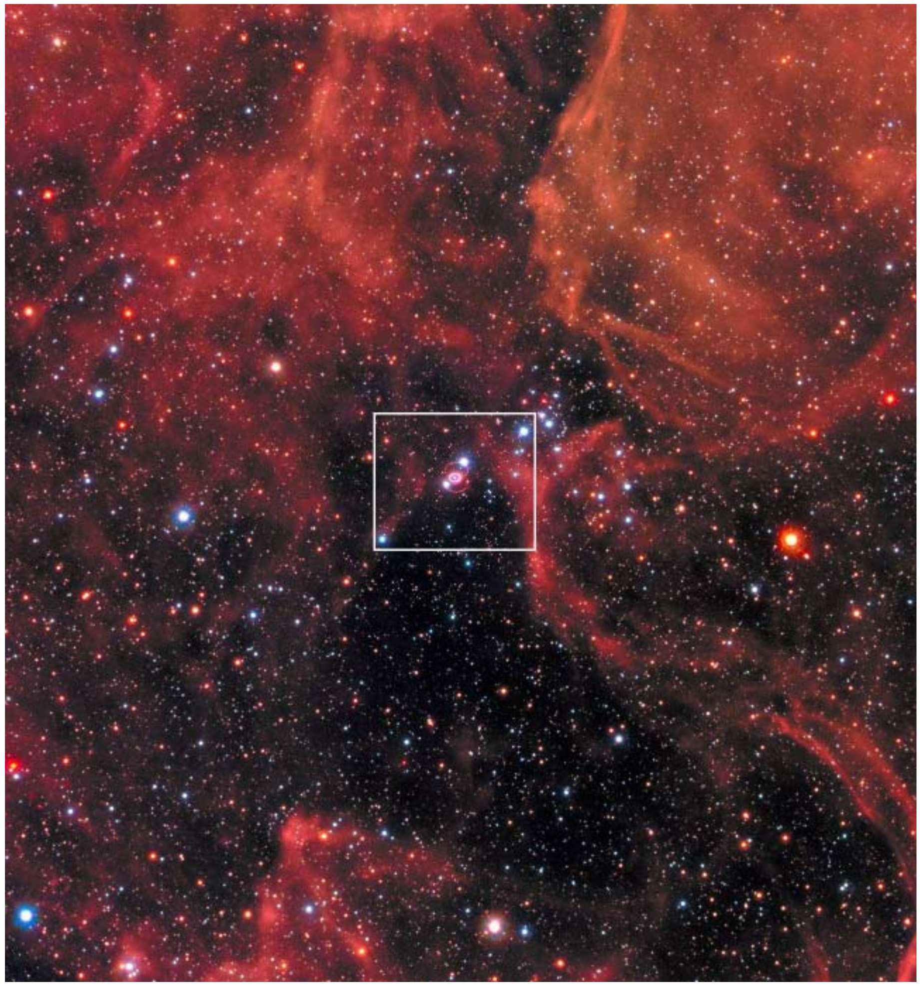
Supernova 1987A (see region outlined at right)

nova 1987A is the circumstellar rings of material seen expanding from the dying star. Since the rings are moving at a speed of 70,000to100,000 miles per hour (much slower than the material ejected in the supernova explosion), scientists theorize that the ring material was expelled before the supernova, while the star was still a red giant.

As Dr. Carl Sagan reminded us: “We are star-stuff.” Almost all of the elements in our universe were created inside stellar factories (nucleosynthesis). However, elements heavier than iron are only created in the final moments of the collapse of a massive star and detonation of the core. So the next time that you admire your gold jewelry, remember that although it may have come from your favorite jeweler, those gold atoms were created in the cataclysmic demise of a star many times more massive than our own.

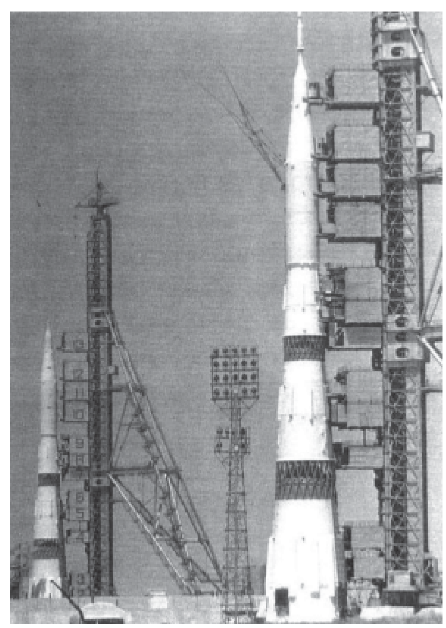
Soviet Moon Program

February marks the beginning of the end of the Soviet Moon program. While publicly denying its intentions to send cosmonauts to the Moon during the 1960s, the Soviets were secretly constructing rockets of mammoth proportions (rivaling the Saturn V). On February 21, 1969, the N1 moon rocket exploded during its first test flight. The rocket fell back to Earth after a safety system mistakenly shut down all 30 engines when a fire was detected in the first stage less than 70 seconds after liftoff. Three more failures would follow before the Soviet government would abandon their manned-Moon program.

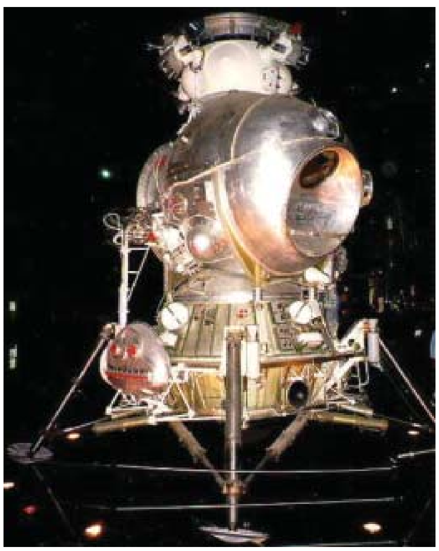


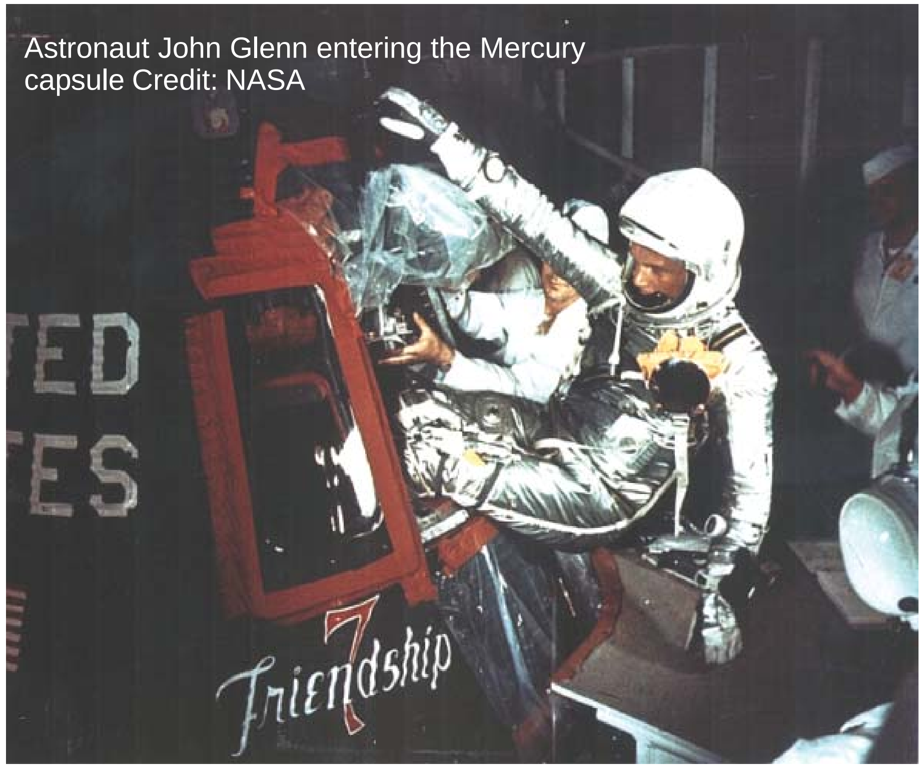
This Hubble Space Telescope image shows Supernova 1987A within the Large Magellanic Cloud, a neighboring galaxy to our Milky Way. **Credits:** NASA, ESA, R. Kirshner (Harvard-Smithsonian Center for Astrophysics and Gordon and Betty Moore Foundation), and M. Mutchler and R. Avila (STScI).

The historic photos that follow are: (1) the N1 under construction with the 30-engine first stage (at right); (2) the Soviet lunar lander; and (3) two N1 rockets on pads at the Baikonur Cosmodrome (also known as Tyuratam) in Kazakhstan. The five stage rockets stood approximately 340 feet high.



N1 Rockets Credit: RKK





Astronaut John Glenn entering the Mercury capsule Credit: NASA

John Glenn and the Flight of Freedom 7

On the morning of February 20, 1962, John Glenn became the first American to orbit the Earth aboard a Mercury space capsule that Glenn named Friendship 7. Originally scheduled for the previous December, the launch was delayed by several technical and mechanical issues, including a fuel leak, and by weather.

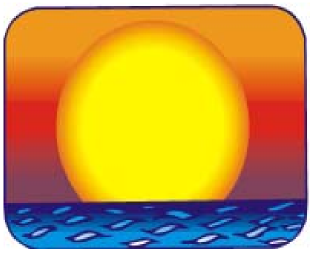
Glenn's capsule was placed into orbit by an Atlas rocket, a rocket originally developed as an Intercontinental Ballistic Missile. While the advantages of a multi-stage rocket were well known in the 1950s (dropping off spent stages reduces the fuel required to place the payload into orbit), starting engines in mid-flight had not been perfected. As such, vehicle weight was reduced during flight of the Atlas by dropping off the two outer engines while its center engine continued to burn until orbit was achieved. The Atlas was also unique in that it relied upon a "balloon" design to minimize its weight. This required pressurization of the fuel tanks so that the booster would not collapse in upon itself.

While no longer a balloon design, the Atlas rocket remains an active expendable launcher today, carrying payloads for NASA, the Air Force and other customers.

Glenn served with the Marine Corps prior to being selected by NASA for its manned spaceflight program. As a fighter pilot, he flew 59 combat missions in the South Pacific during World War II. Following service in the Korean War (baseball Hall of Fame legend Ted Williams was one of his wingmen), he set a speed record for a transcontinental flight on July 16, 1957 when he flew a Vought F8U Crusader from California non-stop to New York in 3 hours 23 minutes in a test of a new Pratt & Whitney engine (it did require 3 mid-air refuelings).

Glenn's trip around the Earth lasted 4 hours and 55 minutes and 23 seconds, completing 3 orbits before splashing down in the Atlantic Ocean southeast of Bermuda. While a public relations success, the flight was not without problems, the most serious of which was an indication that the capsule's heat shield had come loose and its landing bag deployed. Not knowing whether it was a faulty indicator, mission control asked Glenn to leave the retro-pack on during reentry. (The retro-pack consisted of three small rockets that were used to slow the spacecraft down. It was attached to the spacecraft by three straps that extended over the heat shield.) Fortunately, the indicator was faulty and the flaming debris that Glenn saw streaming by his window during reentry was from the retro-pack and not the heat shield.

John Glenn would not return to space for another 36 years. In 1998, at the age of 77, Glenn joined the crew of the space shuttle Discovery for a nine day mission. He was the oldest person to fly in space. John Glenn died Thursday, Dec. 8, 2016 at the age of 95. He was the last of the original Mercury 7 astronauts selected by NASA in 1958 for the agency's fledgling manned spaceflight program.



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
February 1st (EDT)	07:05	17:09
February 15th	06:49	17:27
February 28th	06:29	17:43

Astronomical and Historical Events

1st Centaur Object 32532 *Thereus* at Opposition (11.652 AU)
1st History: loss of the space shuttle Columbia upon reentry (2003)
1st History: launch of Explorer 1; first artificial satellite by the United States (1958)
2nd History: Soviet space station Salyut 4 reenters the Earth's atmosphere (1977)
3rd Aten Asteroid 99942 Apophis closest approach to Earth (1.084 AU)
3rd History: Apollo 14, with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell, lands in the Moon's Fra Mauro region; 3rd manned Moon landing (1971)
3rd History: Soviet spacecraft Luna 9 becomes first spacecraft to soft land on the Moon (1966)
4th New Moon
4th Winter Star Party (through the 10th) on the Florida Keys, Florida
4th History: launch of Lunar Orbiter 3; photographed potential Apollo landing sites (1967)
4th History: Clyde Tombaugh born (1906); discovered the dwarf planet Pluto in 1930
5th Moon at apogee (furthest distance from Earth)
5th Apollo Asteroid 11311 *Peleus* closest approach to Earth (1.704 AU)
5th Apollo Asteroid 1863 *Antinous* closest approach to Earth (1.707 AU)
5th History: flyby of Venus by the Mariner 10 spacecraft on its way to Mercury; first U.S. spacecraft to photograph Venus, first to use gravity of one planet to propel itself to another, and the first spacecraft to visit Mercury (1974)
6th Apollo Asteroid 2013 RV9 near-Earth flyby (0.046 AU)
6th History: Soviet space station Salyut 7 reenters Earth's atmosphere (1991)
7th History: launch of the Stardust spacecraft for a rendezvous with Comet Wild 2 (1999)
7th History: Bruce McCandless makes first untethered spacewalk using a jet-powered backpack (1984)
7th History: Astronomical Society of the Pacific founded (1889)
7th History: William Huggins born, pioneered work in astronomical spectroscopy and first to differentiate nebular and galactic spectra (1824)
8th History: Allende Meteorite fall (meteorites from the fall were the first extraterrestrial rocks analyzed in the NASA Lunar Receiving Laboratory which had just been completed in September of 1967 to support the Apollo program) (1969)
8th Apollo Asteroid 2011 MD closest approach to Earth (1.904 AU)
8th History: discovery of the SAU 094 Mars meteorite in Sayh al Uhaymir, Oman; one of the largest Mars meteorites recovered and the only one with a documented strewn field (2001)
8th History: discovery of GRV 99027 Martian Meteorite on the ice sheet near the Grove Mountain region of Antarctica; the 9.97 gram meteorite was later characterized as a shergottite (2000)
8th History: flyby of Jupiter by the Ulysses spacecraft on its way to study the polar regions of the Sun (1992)
8th History: return of Skylab III crew (astronauts Gerald Carr, William Pogue and Edward Gibson) to Earth after a 3 month stay on the space station (1974)
8th History: Jules Verne born, author and futurist (1828)
9th Second Saturday Stars – Open House at the McCarthy Observatory
9th Atira Asteroid 2010 XB11 closest approach to Earth (0.944 AU)
10th History: flyby of Venus by the Galileo spacecraft (for a gravity assist) on its way to Jupiter; the encounter provided the first views of mid-level clouds on Venus and confirmed the presence of lightning (1990)
10th History: flyby of Mars by the Soviet Mars 4 spacecraft; failed to enter orbit but did detect night-side ionosphere (1974)
10th History: MIT, using Millstone Hill radar in Westford, MA, bounces radar off Venus (1958)
10th History: discovery of Asteroid 624 *Hecktor*, largest Jupiter Trojan, by August Kopff (1907)

mission in the space agency's "Living with a Star" program; five-year mission to study the Sun's energy and its influence on space weather (2010)

11th History: launch of the space shuttle Discovery (STS-82), second Hubble Space Telescope servicing mission; **shuttle tire** on display at the Observatory is from this mission (1997)

11th History: launch of first Japanese satellite: Oshumi (1970)

12th First Quarter Moon

12th Apollo Asteroid 2017 PV25 near-Earth flyby (0.019 AU)

12th History: landing of the Near Earth Asteroid Rendezvous (NEAR) – Shoemaker spacecraft on the asteroid Eros (2001)

12th History: Soviet spacecraft Mars 5 enters orbit around Mars, providing information on surface temperatures, CO_2 concentrations, and detecting a thin ozone layer and water vapor concentrations near the Tharsis region (1974)

12th History: Sikhote Alin meteorite fall in Russia, one of the largest modern falls at 28 tons (1947)

14th History: flyby of Comet Tempel 1 by the Stardust spacecraft (2011)

14th History: NEAR-Shoemaker enters orbit around *Eros*, one of the largest of the near-Earth asteroids (2000)

14th History: Voyager 1 points its camera back towards the Sun and takes a family portrait, capturing six planets (Venus, Earth, Jupiter, Saturn, Uranus and Neptune) from a distance of approximately 4 billion miles; Mercury was too close to the Sun to be seen and Mars was lost in the scattered sunlight (1990)

14th History: launch of the Solar Maximum Mission (1980) to study the Sun during the peak of the solar cycle; a malfunction less than a year later cut the mission short. However, the satellite was recovered and repaired by the Space Shuttle Challenger in April 1984; operated successfully until burning up in the Earth's atmosphere in December 1989

14th History: launch of Luna 20, Soviet Moon sample return (1972)

14th History: launch of Syncom 1, the first geosynchronous satellite (1963)

15th History: meteor explodes over the Russian city of Chelybinsk causing hundreds of minor injuries (2013)

15th History: discovery of Centaur Object *Chariklo* by Jim Scotti (1997)

15th History: flyby of the Moon by the Hiten spacecraft; Earth orbiting satellite designed by the Japanese Space Agency to test technologies for lunar and planetary missions (1992)

15th History: Pioneer 10 becomes the first spacecraft to traverse the Main Asteroid Belt (1973)

15th History: Galileo Galilei born (1564)

16th Comet 10P/Tempel at Opposition (3.567 AU)

16th Aten Asteroid 367943 *Duende* closest approach to Earth (0.481 AU)

16th Atira Asteroid 2015 DR215 closest approach to Earth (1.208 AU)

16th Aten Asteroid 341843 (2008 EV5) closest approach to Earth (1.644 AU)

16th History: Gerard Kuiper discovers Uranus' moon *Miranda* (1948)

17th History: discovery of the Plutino 90482 *Orcus* with its large moon, Vanth, by American astronomers Michael Brown of Caltech, Chad Trujillo of the Gemini Observatory, and David Rabinowitz of Yale University (2004)

17th History: Ann Harch discovers *Dactyl*, the first natural satellite of an asteroid (*Ida*) discovered from Galileo Images (1994)

17th History: launch of Ranger 8; lunar impact mission (1965)

17th History: launch of NEAR spacecraft, asteroid orbiter/lander; first of NASA's Discovery missions and the first mission to go into orbit around an asteroid (1996)

17th History: launch of Vanguard 2; designed to measure cloud-cover distribution over Earth (1959)

18th Scheduled launch of a SpaceX Falcon 9 rocket from the Cape Canaveral Air Force Station, Florida. Payload will include Israel's SpaceIL, privately-funded lunar lander

18th Apollo Asteroid 2016 CA138 near-Earth flyby (0.055 AU)

18th History: Mike Brown and Jean-Luc Margot's discovery of *Romulus*, the larger of two moon that orbit Asteroid 87 *Sylvia* (2001)

18th History: American astronomer Clyde Tombaugh discovers Pluto (1930)

19th Full Moon

19th Moon at perigee (closest distance from Earth)

19th Apollo Asteroid 3360 *Syrinx* closest approach to Earth (3.036 AU)

19th History: Nicolas Copernicus born (1473)

20th Apollo Asteroid 455176 (1999 VF22) near-Earth flyby (0.049 AU)

20th History: Clementine spacecraft enters lunar orbit and starts photographic survey; joint project between the Strategic Defense Initiative Organization and NASA, first of a new class of small spacecraft to enable long-duration, deep space missions at low cost using lightweight satellite technology (1994)

20th History: launch of the core module of the Soviet space station Mir (1986)

20th History: launch of Mercury-Atlas 6 and Friendship 7 with astronaut John Glenn; first American in orbit (1962)

Astronomical and Historical Events (continued)

21st Kuiper Belt Object 55565 (2002 AW197) at Opposition (44.403 AU)
21st History: Soviet moon rocket (N-1) explodes during first test flight (1969)
22nd Apollo Asteroid 2016 CO246 near-Earth flyby (0.041 AU)
22nd Kuiper Belt Object 148209 (2000 CR105) at Opposition (61.109 AU)
22nd History: launch of Viking, Sweden's first satellite (1986)
22nd History: launch of Soviet spacecraft Kosmos 110, with dogs Veterok and Ugolyok (1966)
22nd History: Max Wolf discovers asteroids 587 *Hypsipyle* and 588 *Achilles* (1906)
23rd Scheduled launch of a SpaceX Falcon 9 rocket with a Crew Dragon spacecraft on an unmanned test flight to the International Space Station from the Kennedy Space Center, Florida
23rd History: Supernova 1987A detected in the Large Magellanic Cloud (1987)
24th History: launch of the Space Shuttle Discovery (STS-133) on its final mission. The shuttle delivered space parts and critical components to the ISS (2011)
24th History: launch of Mariner 6; Mars flyby mission returned images showing the south polar cap as being composed predominantly of carbon dioxide; refined estimates of the mass, radius and shape of Mars (1969)
24th History: Jocelyn Bell announces discovery of rapidly rotating radio sources, later determined to emanate from neutron stars or pulsars (1968)
24th History: launch of Bumper WAC, first two-stage liquid-propellant rocket and the first human-made object to achieve hypersonic speeds (1949)
25th Comet 46P/Wirtanen at Opposition (0.517 AU)
25th History: flyby of Mars by the Rosetta spacecraft (2007)
25th History: Soviet spacecraft Luna 20 returns lunar soil sample (30 grams) to Earth (1972)
26th Last Quarter Moon
26th Apollo Asteroid 2017 DR109 near-Earth flyby (0.058 AU)
26th Apollo Asteroid 9162 *Kwiila* closest approach to Earth (0.544 AU)
26th History: launch of the first Saturn 1B rocket booster (1966)
27th Mercury at its Greatest Eastern Elongation (separation from the Sun in the early evening sky) (18°)
27th Apollo Asteroid 2016 FU12 near-Earth flyby (0.040 AU)
27th Apollo Asteroid 2018 DE1 near-Earth flyby (0.051 AU)
27th History: discovery of Jupiter's moon Herse was by Brett J. Gladman, John J. Kavelaars, Jean-Marc Petit, and Lynne Allen (2003)
28th Amor Asteroid 7336 *Saunders* closest approach to Earth (2.340 AU)
28th History: flyby of Jupiter by the New Horizons spacecraft bound for Pluto (2007)
28th History: launch of Discoverer 1; first of a series of satellites which were part of the Corona reconnaissance satellite program and first satellite launched into polar orbit (1959)

Commonly Used Terms

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

References on Distances

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

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

Solar Activity

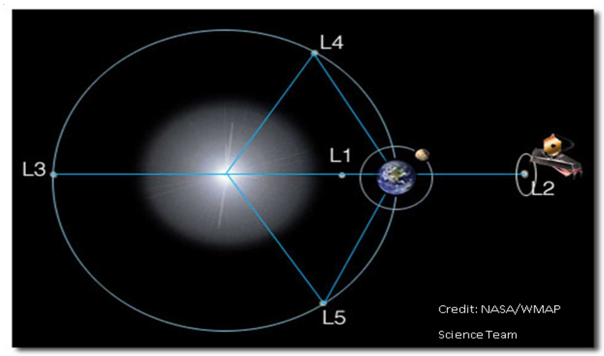
For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out *www.spaceweather.com.*

International Space Station and Iridium Satellites

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

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and future location of the James Webb telescope) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



NASA's Global Climate Change Resource

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

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Second Saturday Stars poster: Marc Polansky

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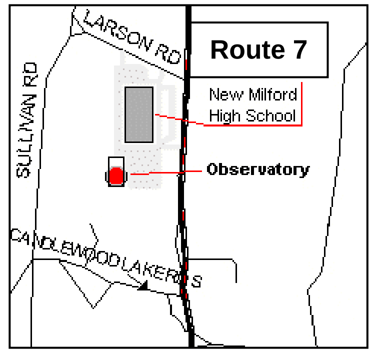

www.mccarthyobservatory.org

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@McCarthy Observatory

mccarthy.observatory@gmail.com

@JJMObservatory

Second Saturday Stars

FREE EVENT

Every Month at the

John J. McCarthy Observatory

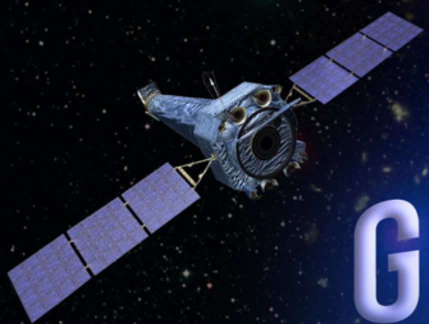
Behind the New Milford High School

860.946.0312

www.mccarthyobservatory.org

February 9th

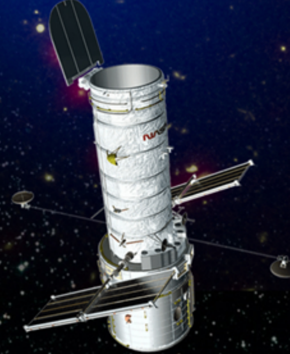
7:00 - 9:00 pm



NASA's

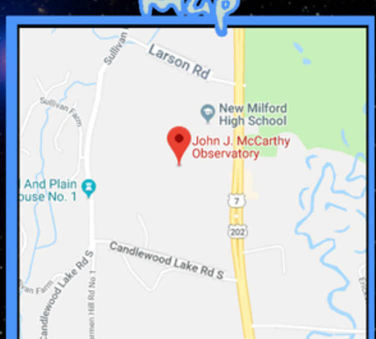
GREAT SPACE OBSERVATORY

PROGRAM



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

Map



February 2019

Celestial Calendar

Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday

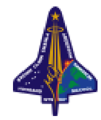
Phases of the Moon

Feb 4 Feb 12 Feb 19 Feb 26

1

Launch of Explorer I (1958)

Space Shuttle Columbia breaks up on reentry from orbit (2003)



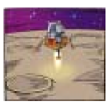
2

Soviet space station, Salyut 4 reenters Earth's atmosphere (1977)

3

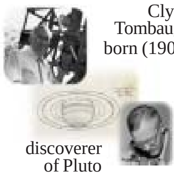
Chinese New Year

Soviet Luna 9 lands on Moon (1966)



Apollo 14 - 3rd Moon landing- Shepard, Roosa, Mitchell (1971)

4



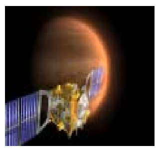
Clyde Tombaugh born (1906)

discoverer of Pluto

Launch of Lunar Orbiter 3, to locate Apollo landing sites (1967)

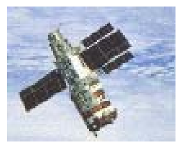
5

Moon at apogee (farthest from Earth)



Flyby of Venus by Mariner 10 spacecraft en route to Mercury (1974)

6



Soviet space station Salyut 7 reenters Earth's atmosphere (1991)

7

William Huggins born, pioneer of astronomical spectroscopy (1824)

Astronomical Society of the Pacific founded (1889)

Launch of Stardust spacecraft for rendezvous with comet Wild 2 (1999)

8

Jules Verne born (1828)

Mars meteorites found - Oman (2001); Antarctica (2000)

Return of Skylab 3 crew after 3 months on space station (1974)

9

Astronaut Bernard A. Harris becomes first African-American to perform extra vehicular activity, during shuttle mission STS-63 to Mir spacecraft, flown by first woman shuttle pilot, Eileen Collins (1995)

2nd Saturday Stars Open House McCarthy Observatory

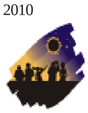
10

Flyby of Venus by Galileo spacecraft on way to Jupiter (1990)

Flyby of Mars by Soviet Mars 4 spacecraft (1974)

11

Launch of NASA Solar Dynamics Observatory 2010

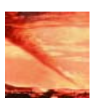


A solar eclipse inspires Nat Turner to launch slave revolt in Virginia (1831)

Launch of Japanese satellite Oshumi (1970)

12

NEAR spacecraft lands on asteroid Eros (2001)



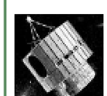
Sikhote Alin meteorite falls in Russia (1947)

Soviet Mars 5 spacecraft in orbit (1974)

13

John Louis Emil Dreyer born, Danish/Irish astronomer and biographer of Tycho Brahe; continued Herschel's work by publishing catalogue of nebulae and clusters (1852)

14

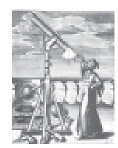


Launch of Syncom 1, first geosynchronous satellite (1963)

Launch of Solar Maximum Mission to study Sun during peak of cycle (1980)

Flyby of Comet Tempel 1 by the Stardust spacecraft (2011)

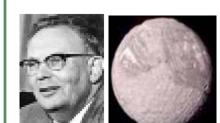
15



Galileo Galilei born (1564)

Flyby of Moon by Japan's Hiten spacecraft (1992)

16



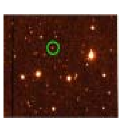
Gerard Kuiper discovers Uranus' moon, Miranda (1948)

17

Launch of Ranger 8, Moon impact mission (1965)

Launch of Vanguard 2, to measure Earth cloud cover (1959)

Plutino 90482 Orcus discovered - has one moon, Vanth (2004)

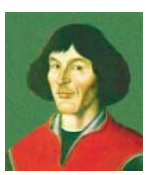


18

American astronomer Clyde Tombaugh discovers Pluto (1930)

19

Moon at perigee (closest distance to Earth)



Nicholas Copernicus born (1473)

20

Launch of Mercury Atlas 6 and Friendship 7 with John Glenn, 1st American in orbit (1962)

Launch of core module of Soviet Mir space station (1986)

Winter Star Party at Big Pine Key, Fl. (thru Sunday the 26th)

21

Soviet Moon rocket (N-1) explodes (1969)

Tom Gehrels born, astronomer and co-discoverer of over 4,000 asteroids (1925)

22

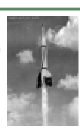
Launch of Soviet spacecraft Kosmos 110, with dogs Veterok and Ugolyok (1966)

23

Supernova 1987A detected in Large Magellanic Cloud (1987)

24

Launch of Bumper WAC, first two-stage liquid ropellant rocket (1949)

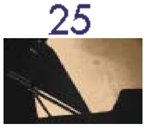


Launch of Mariner 6, Mars flyby (1969)

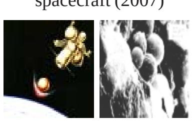
Jocelyn Bell's discovery of pulsars (1968)

Shuttle Discovery final mission (2011)

25



Flyby of Mars by Rosetta spacecraft (2007)



Soviet spacecraft Luna 20 returns 30-gram soil sample to Earth (1972)

26

Launch of first Saturn 1B rocket booster (1966)

27

Bernard Ferdinand Lyot born, French astronomer and inventor of the coronagraph to observe the sun's corona without waiting for an eclipse, (1897)

28

Launch of Discoverer 1, first of Corona reconnaissance satellite program (1959)

Flyby of Jupiter by New Horizons spacecraft bound for Pluto (2007)