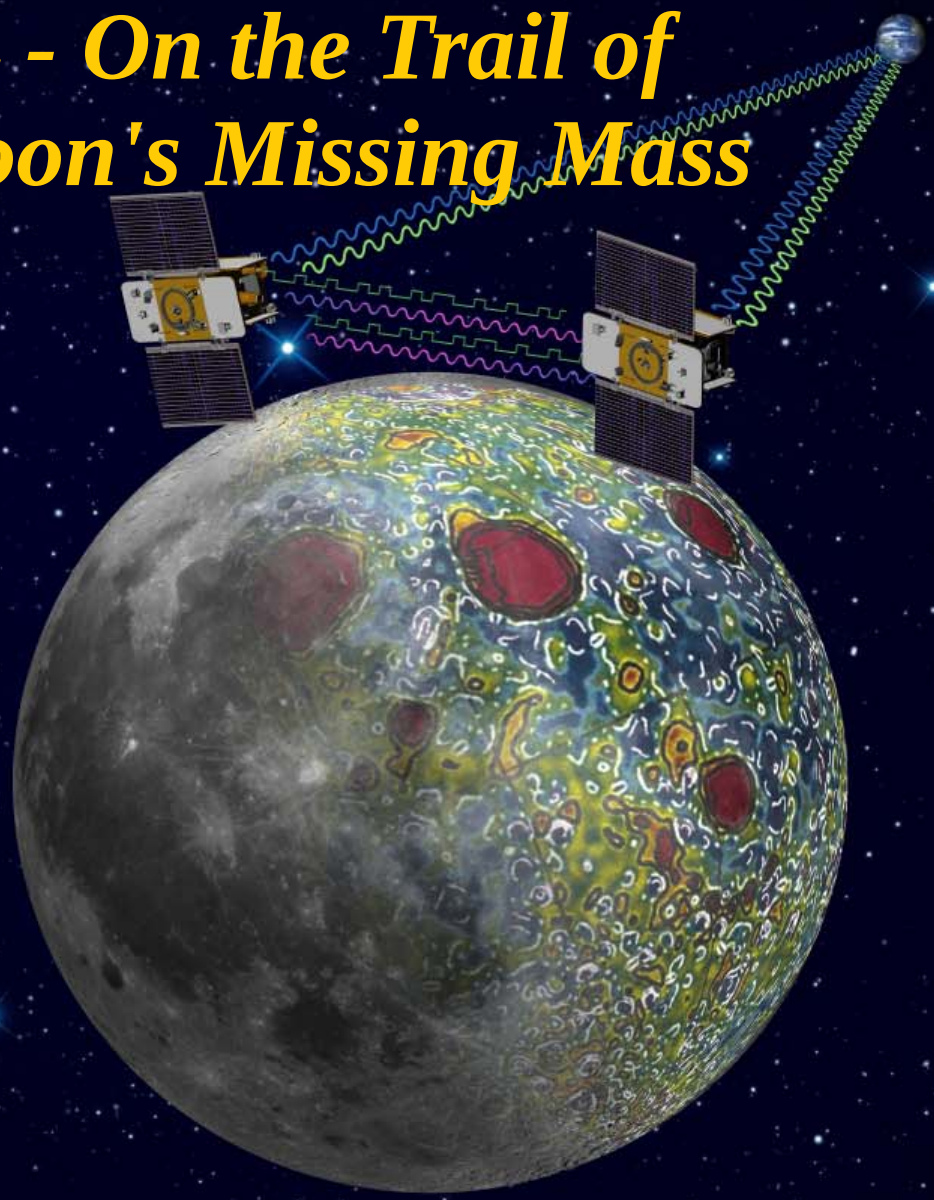
Galactic Observer

John J. McCarthy Observatory

Volume 9, No. 3 March 2016

GRAIL - On the Trail of the Moon's Missing Mass



GRAIL (Gravity Recovery and Interior Laboratory) was a NASA scientific mission in 2011/12 to map the surface of the moon and collect data on gravitational anomalies. The image here is an artist's impression of the twin satellites (Ebb and Flow) *orbiting in tandem above a gravitational image of the moon.*

See inside, page 4 for information on gravitational anomalies (mascons) or visit http://solarsystem.nasa.gov/grail.

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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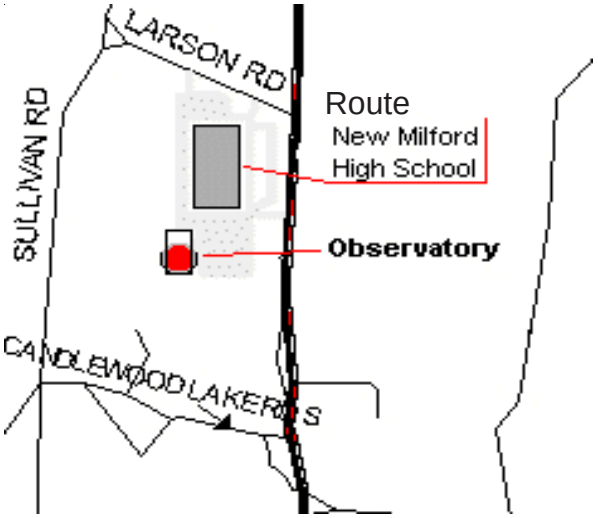

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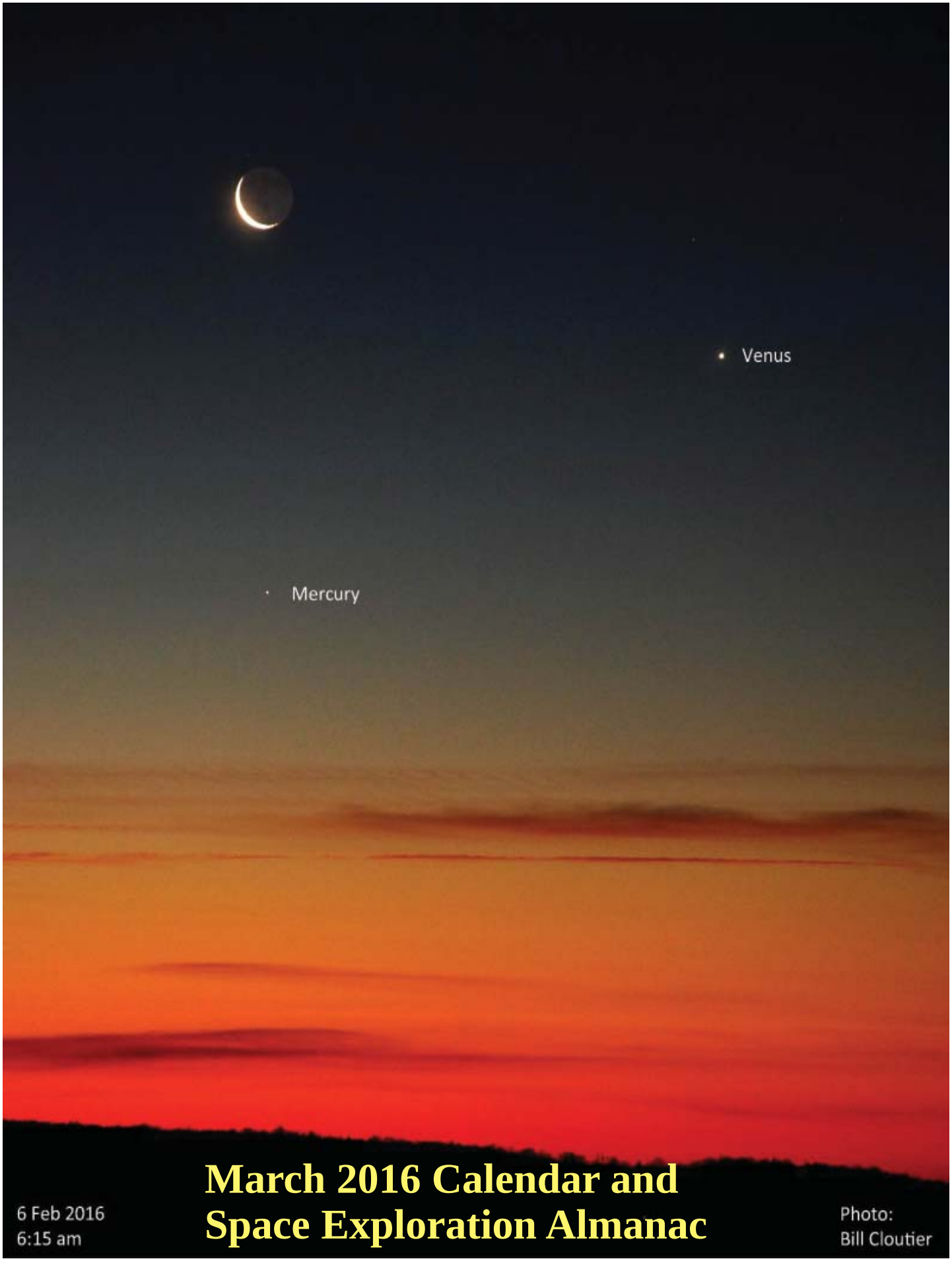
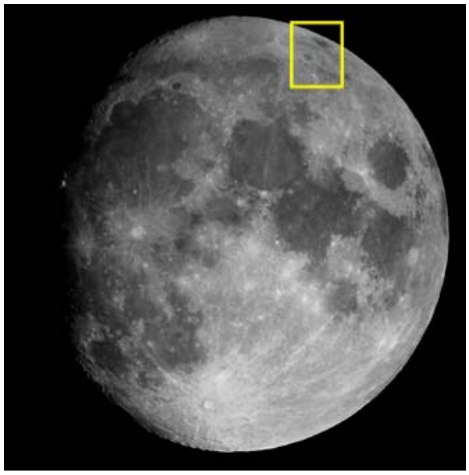


March 2016 Calendar and Space Exploration Almanac

"Out the Window on Your Left"

It's been almost 45 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).



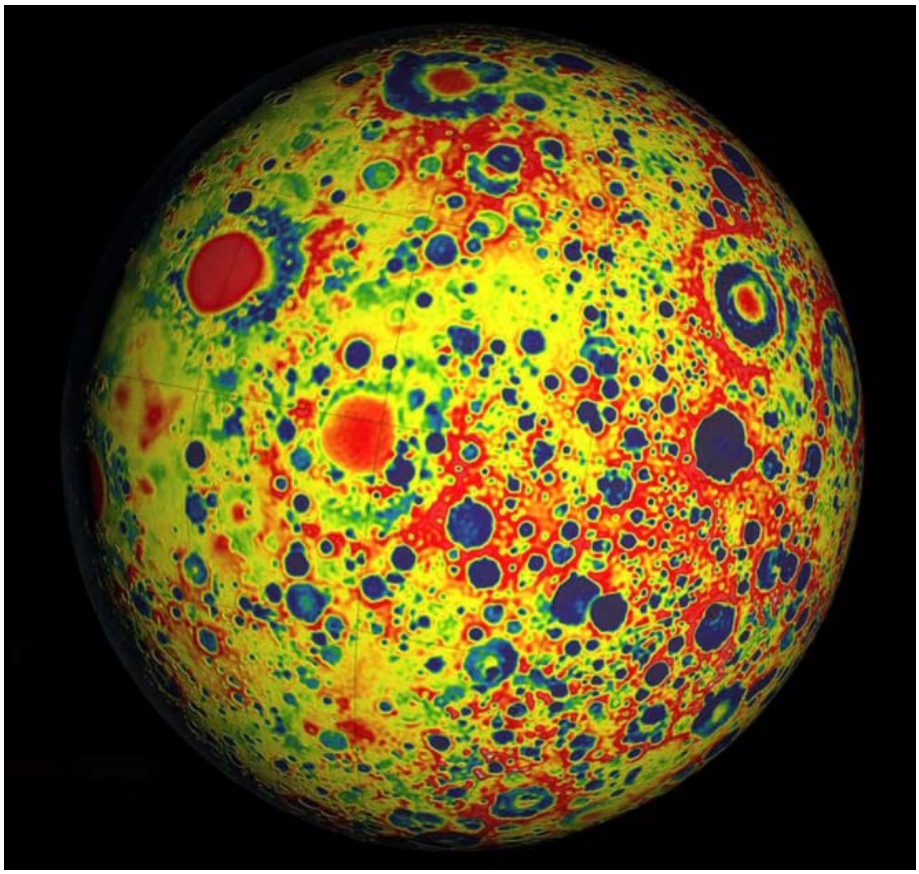
Lunar seas are actually expansive low-lying plains formed by ancient lava flows

The Sun is high in the sky above the Moon's northeastern limb this month. Details of the ancient landscape have disappeared with the Sun overhead, with the exception of isolated dark patches of lava and the mare (a relatively flat lava plain) on the limb.

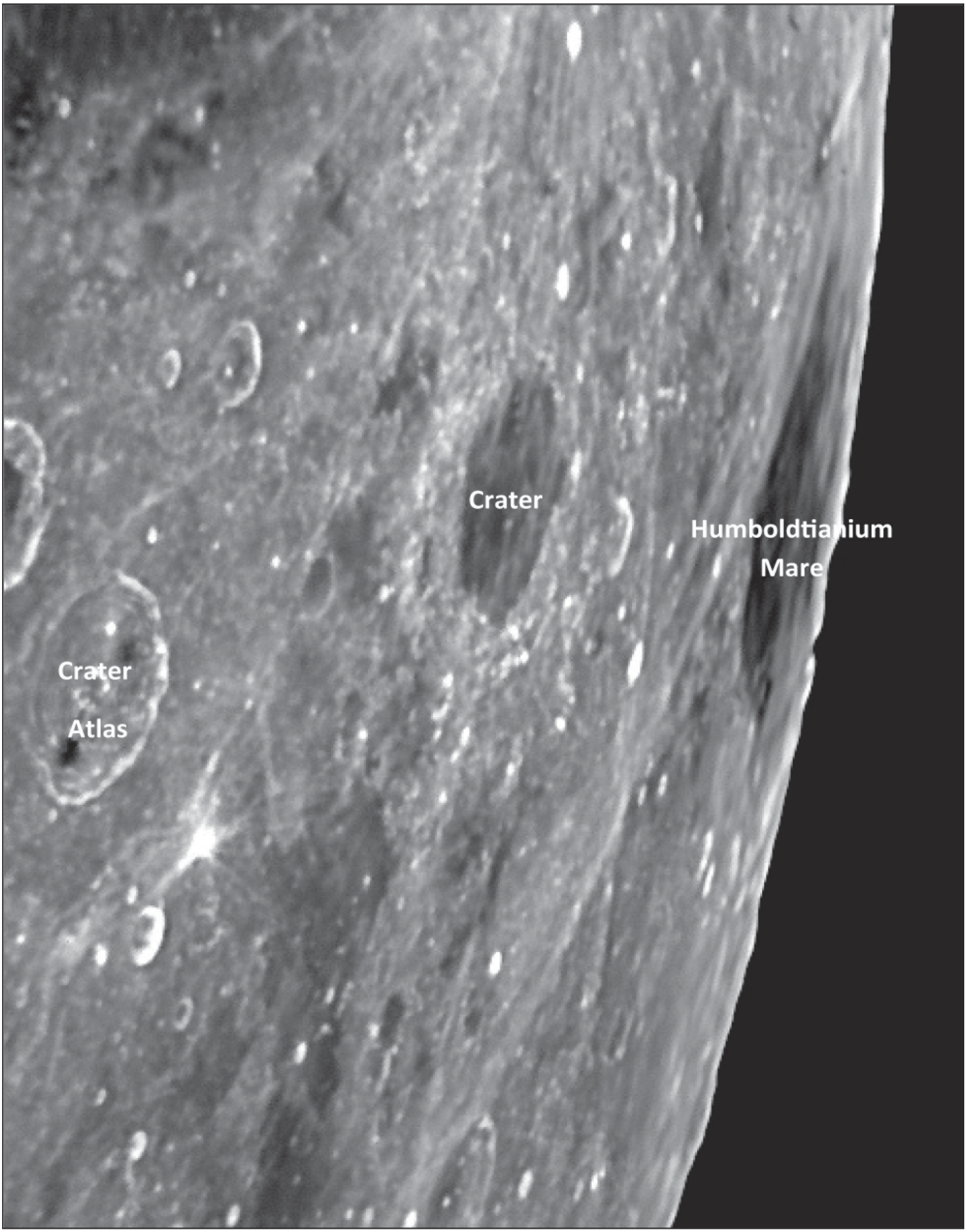
Our view of the Humboldtianum impact basin is foreshortened (elongated) due to its position on the limb. The basin extends onto the far side, revealing its entire structure only when the northeastern limb is tipped toward the Earth. There are remnants of 4 to 6 concentric mountain rings produced by the impact; the largest and most defined is over 400 miles (650 km) in diameter.

The formation of the impact basin dates to the Nectarian epoch, one of the Moon's earliest geologic periods. The inner ring of the basin was subsequently flooded during a prolonged period of lunar volcanism. Mare Humboldtianum (named after Alexander von Humboldt) has a diameter of approximately 170 miles (273 km). At the center of the basin is a mascon (mass concentration) that was detected by the Lunar Prospector spacecraft. Mascons were first discovered in the 1960s, when their localized gravity fields disrupted the predicted path of orbiting spacecraft. Their origin wasn't completely understood until the GRAIL spacecrafts provided additional insight into the structure of the Moon's interior. In the formation of an impact basin (a crater more than 186 miles or 300 km across) rock from the Moon's crust and underlying mantle is melted at the point of impact. Melting increases the density of the material and the mass slumps toward the bottom of the crater. The mass is then covered by the collapse of the surrounding crust. Mascons have been found in basins with and without an overlying layer of mare lava.

Mare Humboldtianum is only one of two maria named after individuals (Mare Smythii is the other). Alexander von Humboldt (1769 - 1859) was a Prussian geographer, naturalist, and explorer. He was one of the first to propose that the South American and African continents were once part of a larger super continent. He is recognized for his study of new and previously unexplored lands on several continents.



A gravitational map of the moon's far side
Source: Caltech/MIT/GSFC



Mare Humboldtianum and the Northeast Limb

One Year in Space

NASA astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko were scheduled to return to Earth on March 1st after spending almost a year aboard the International Space Station (ISS). Researchers are anticipating that their year in a weightless environment will provide additional insight into the health challenges of long-duration space flight: for example, to Mars.

Areas of research include:

- Changes in physical performance
- Behavioral health and the psychological effects of long-duration spaceflight including confinement
- Visual impairment possibly due to pressure changes in the brain and spinal fluid in a weightless environment
- Changes to the immune system
- Atherosclerosis (hardening and narrowing of the arteries)
- Human factors (for example, retention of fine motor skills and training, decision making, alertness and reasoning)
- Changes in the major organs, muscle and brain over time
- Changes in the digestive system and organisms within the gastrointestinal tract

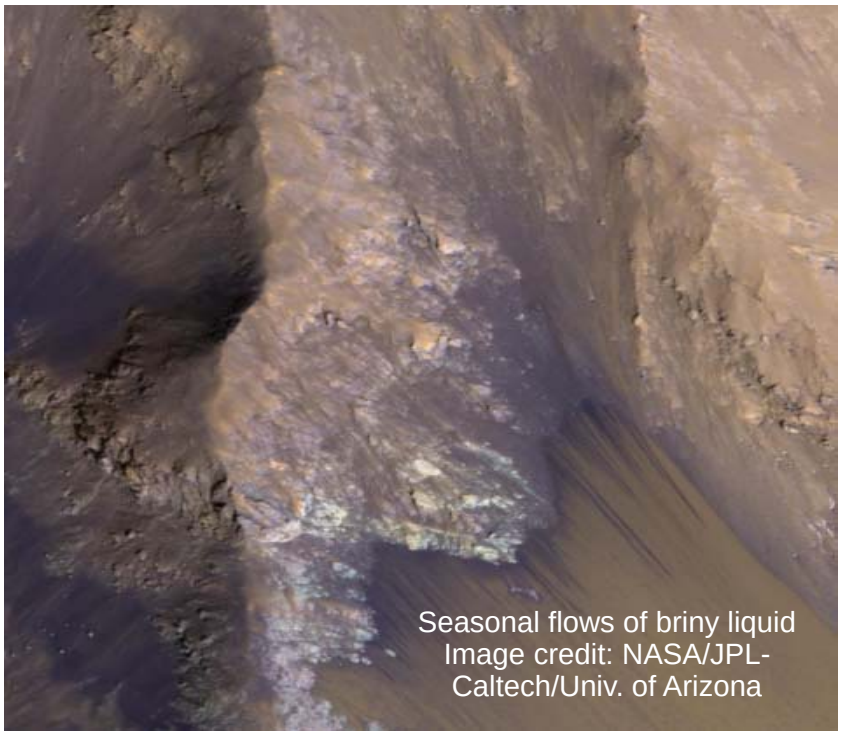
There is another, unique aspect to the experiment: Scott Kelly has an identical twin. Mark Kelly, a retired astronaut (in 2011), volunteered to be part of the study as a control subject. Mark has been monitored on the ground throughout the mission and will continue to be after Scott returns from space. In studying the twins, researchers may be able to detect very subtle changes in an individual with the same genetic makeup after a year in space.

Kelly set the record for U.S. astronauts for cumulative days in space in October (382 days over four missions). He is also the U.S. record holder for consecutive days in space (previously held by astronaut Mike Fincke). When Kelly returns to Earth, he will have compiled over 500 days living in space. Cosmonaut Gennady Padalka holds the overall record with 879 cumulative days in orbit.

Scott Kelly and Mikhael Kornienka aboard the International Space Station

Ten Years on Orbit

NASA's Mars Reconnaissance Orbiter (MRO) has been orbiting the Red Planet for 10 years (since its arrival on March 10, 2006). Passing over the planet's poles, the spacecraft completes 12 orbits a day (it has completed more than 40,000 orbits). At an altitude of 186 miles (300 km), MRO's longevity has made is possible to monitor daily (and seasonal) changes on the surface as well as in the Martian atmosphere.



Seasonal flows of briny liquid
Image credit: NASA/JPL-Caltech/Univ. of Arizona

The image of a ridgeline (previous page) within Coprates Chasma highlights one of many discoveries by MRO. The 600 mile (966 km) long canyon is part of the larger Valles Marineris canyon system. MRO has recorded the appearance of dark streaks on the sandy slope during the warm weather that fade and disappear with colder temperatures. The streaks appear to originate from the bright bedrock and are believed to be comprised of a salty brine – the first direct evidence of liquid water on the surface of Mars.

Fueled and Ready for Flight

The European Space Agency (ESA) is preparing to launch an orbiter and demonstration lander to Mars (March 14th). Roscosmos, the Russian Federal Space Agency, and mission partner will be providing the Proton rocket for the launch. The 2016 ESA mission is a precursor to a more ambitious mission scheduled to be launched in 2018 (at the next Opposition of Mars).

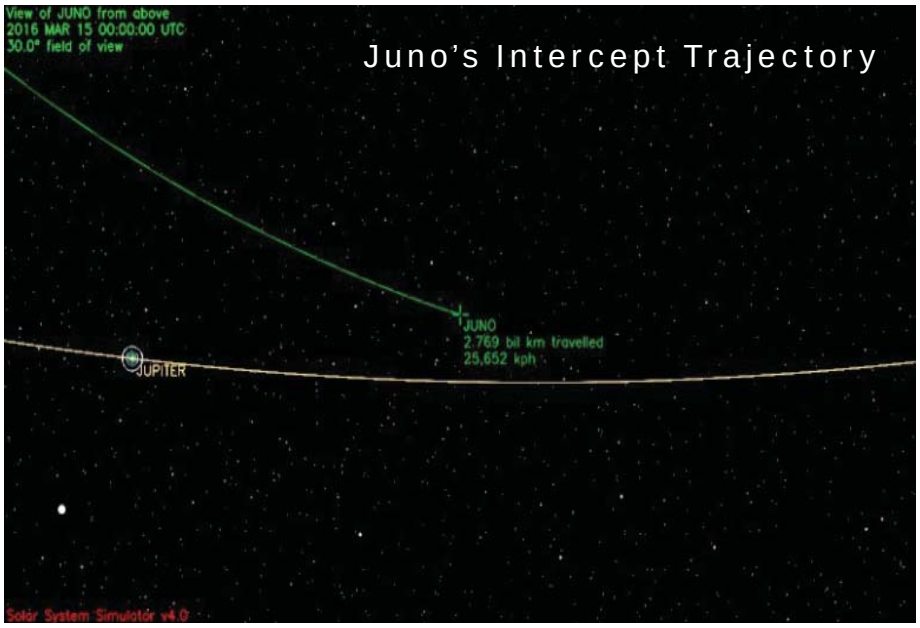
The 2016 mission includes the ExoMars Trace Gas Orbiter (TGO), designed to detect trace atmospheric gases that could be markers for life (microbe activity) on the planet. The data collected by the TGO will be used to identify and select potential landing sites for an ESA exobiology rover on the 2018 mission.

The 2016 lander (Schiaparelli) is designed to assess landing performance technology. The 1,330 pound (600 kg) lander will enter Mars atmosphere in October at an altitude of 76 miles (122.5 km) and at a speed of 13,000 miles per hour (21,000 kph). Its aerodynamic heatshield will slow the payload until a parachute can be deployed. Nine hydrazine-fueled rocket motors will be used for the final descent onto Meridiani Planum once the parachute is jettisoned. The lander's battery operated science payload is expected to operate for several sols (Martian days).

Operators load the lander with toxic hydrazine fuel
Credit: ESA -T. Walloschek

Juno Update

Juno was launched in August 2011 and is scheduled to arrive at Jupiter on July 4, 2016. The diagram produced by the Jet Propulsion Laboratory's Solar System Simulator (*http://space.jpl.nasa.gov/*) for March 15th shows the position of the Juno spacecraft (in green).



Jupiter at Opposition

The Earth comes between the Sun and Jupiter in its orbit on March 8th (this arrangement is known as Opposition since Jupiter is opposite the Sun in the sky). On that day, Jupiter will rise with

the setting Sun and be visible all night long, appearing highest in the sky in the south at midnight. Jupiter will remain in the evening sky until September when it passes behind the Sun, as viewed from Earth.

Jupiter can be found in the constellation Leo. At a magnitude of -2.3, it will be one of the brightest star-like objects in night sky. On March 8th, the gas giant will be 412.3 million miles (4.4354 AU) from Earth or 37 light minutes.

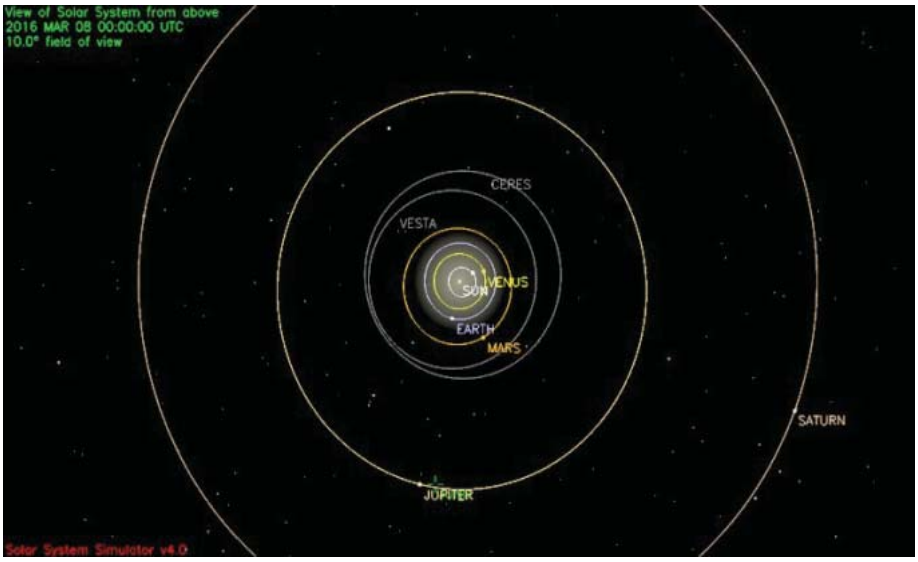
Jupiter reaches Opposition every 399 days, about a month later each successive year. It is one of the only planets that displays surface (atmospheric) details through a moderately sized telescope. With its rapid rotation (approximately every 10 hours), the planet's cloud belts and storms provide the observer with an ever-changing, dynamic display.

Jupiter's four Galilean moons (discovered by Galileo in 1610) appear as stars along the planet's equatorial plane. Their motion is discernable over the course of a single night.

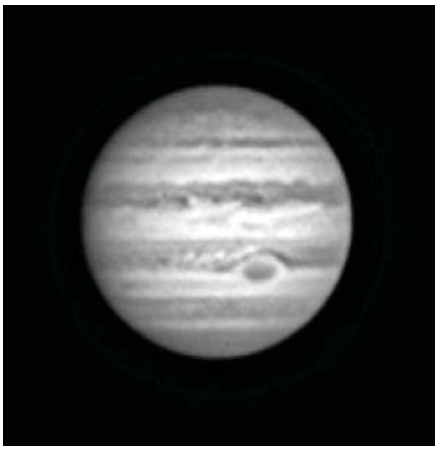
Io, Europa and Ganymede are tidally locked, with one side of the moon(s) always facing Jupiter. In their synchronistic orbits, Io completes four orbits of Jupiter (in 1.77 days) and Europa two orbits of Jupiter (in 3.55 days) in the time Ganymede completes one orbit (in 7.2 days).

Ganymede is the largest moon in the solar system with a diameter greater than the planet Mercury. Callisto has the oldest and most heavily cratered surface. Furthest from Jupiter, the fourth Galilean moon is tidally locked but not in orbital resonance with the inner three Galilean moons.

Three of the four Galilean moons (excluding Io) may have subsurface oceans. Europa will be the target of several future missions, including ESA's *Jupiter Icy moons Explorer* and NASA's *Europa Multiple-Flyby Mission.*



Since Europa is embedded in Jupiter's magnetosphere, the NASA spacecraft will spend a majority of its time outside the high radiation regions, diving in for brief flybys of the icy moon. If the mission includes a lander, it could parked in a safe, low radiation, orbit until a suitable landing area on Europa can be identified.



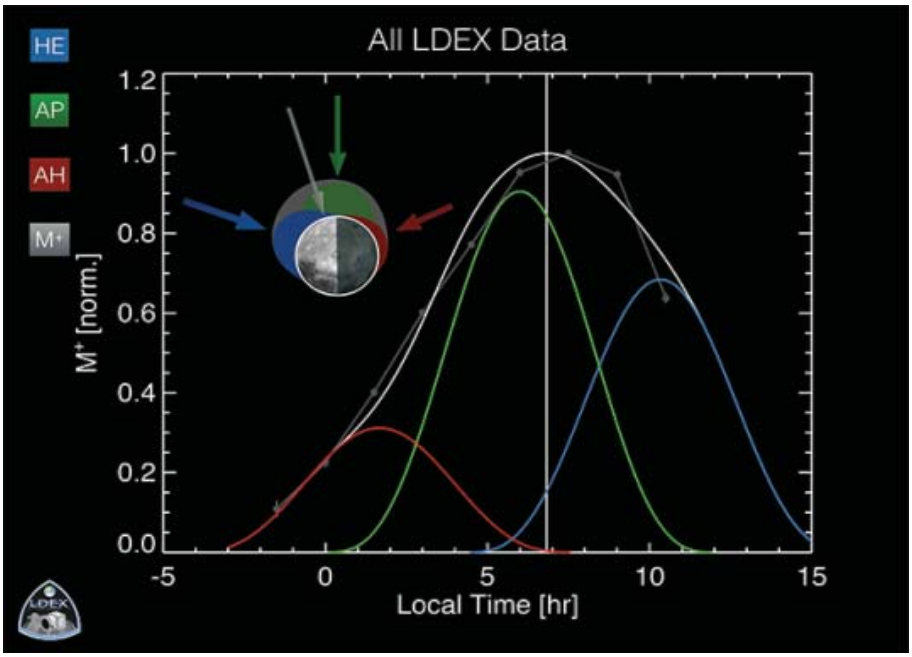
Jupiter photo: Bill Cloutier

Dusty Moon

NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE) spent six months orbiting the Moon. Arriving in October 2013, the spacecraft gathered information on the Moon's exosphere, an almost vacuous envelop of gas molecules, replenished from sources such as the solar wind. From its science orbit, at an altitude as close as 12 miles (20 km) above the lunar surface, LADEE discovered a dust cloud surrounding the Moon, a cloud produced by the bombardment of meteoroids and interplanetary dust particles (particles that are vaporized by Earth's thick atmosphere).

The dust cloud encircling the Moon increases in density during Earth and Moon in their circuits around the Sun intercept clouds of dust and debris left behind by periodic comets). There are also sporadic impacts from interplanetary dust particles. LADEE found that the cloud size and density is sensitive to the particle's impact velocity as well as the Moon's location in its orbit (peaking when the Moon is in its waning gibbous phase).

In the diagram (below), interplanetary dust particles moving away from the Sun and crossing the Earth's orbit comprise the Helion (HE) source. Those same



Best total M+ fit (black) for ejecta (dust) sources Credit: J.Szalay

particles moving back towards the Sun comprise the antihelion (AH) source. The Apex (AP) source are retrograde (moving in the opposite direction to the motion of the planets around the Sun) particles with the highest impact velocities. They are believed to come from the remnants of long-period comets in their travels through the inner solar system. Impacts of AP particles (at velocities exceeding 21 miles per second or 34 km/s) vaporize the incoming particles, as well as some of the lunar soil, while temporarily ejecting thousands of smaller particles into the Moon's exosphere.

China's Moon Exploration Program

China's National Space Administration recently released high definition photos of its first successful soft-landing on the Moon in December 2013. The Chang'e 3 lander set down on the lava plains of Mare Imbrium, just east of Sinus Iridium (Bay of Rainbows). The lander carried a small rover that operated for two lunar days before succumbing to the inhospitable lunar temperatures.

The panorama (below) was taken by the Yutu rover. The Chang'e 3 lander is visible in the distance.

Photo: Chinese Academy of Sciences / China National Space Administration / The Science and Application Center for Moon and Deepspace Exploration / Emily Lakdawalla

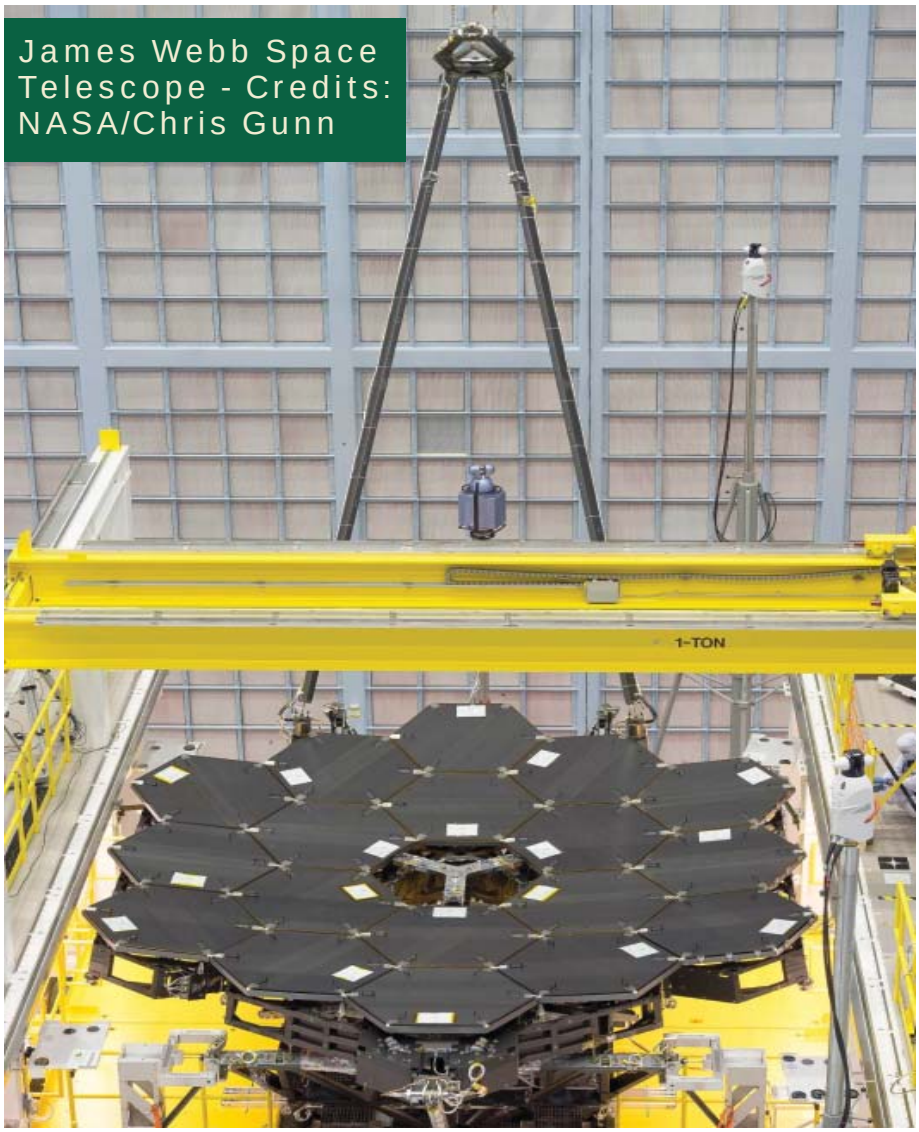
James Webb Assembly Milestone

On February 3rd, the eighteenth and final mirror was installed onto the James Webb Space Telescope support structure at the Goddard Space Flight Center. Each hexagonal-shaped mirror is approximately 4.2 feet (1.3 meters) across. The eighteen mirror segments are designed to function as an equivalent 21.3 foot (6.5 meter) diameter mirror once deployed.

Once the remaining instrumentation and optics are installed, the complete assembly will be shipped to the Johnson Space Center for final testing and preparation for launch in 2018 from ESA's launch facility in French Guiana.

The telescope will be positioned at the Earth-Sun L2 Lagrange point, approximately 1 million miles (1.5 million km) from Earth, in the exact opposite direction from the Sun. The L2 position allows the telescope to maintain a relatively fixed position relative to the Earth and Sun. Its distant location and large sunshield allow the telescope to be cooled to -370°F, enabling infrared light observations without the interference from nearby heat sources.

Next Generation Space Telescope



James Webb Space Telescope - Credits: NASA/Chris Gunn

Castor and Multiple Star Systems

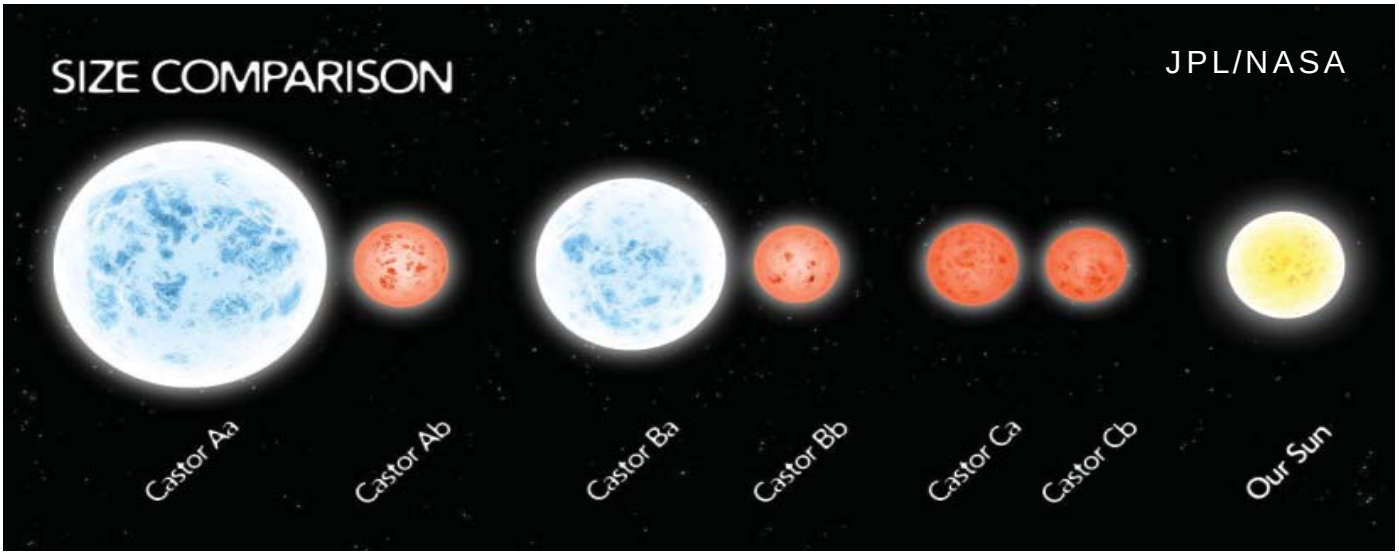
In 1941, John Campbell, the editor of Astounding Science Fiction magazine, asked Isaac Asimov to write a story about people living on a planet in a six star system where darkness comes only once every 2,000 years. The result was "Nightfall," recognized as one of the best science fiction stories.

Planets orbiting multiple star systems was the realm of science fiction until just 27 years ago. In 1989, a large exoplanet was detected in the HD 114762 double star system located in the constellation Coma Berenices, 130 light years from Earth. The exoplanet, approximately 11 times the mass of Jupiter, orbits a yellow-white main sequence star. The second, smaller star in the system is a red or brown dwarf. Seventeen years later, an exoplanet (less than twice the mass of Jupiter) was discovered in the 16 Cygni triple star system in the constellation Cygnus, 69 light years from Earth. This star system includes two yellow dwarfs (similar in size to our Sun) and a smaller, red dwarf. In 2009, an exoplanet 10 times the mass of Jupiter was found in the 30 Arietis quadruple star system in the constellation Aries, 136 light years from Earth. This system is comprised of two double stars orbiting a common point in space. The exoplanet orbits one the two primary stars (30 Arietis B) which is slightly more massive than our Sun.

Since 1989, according to the Exoplanet Catalogue (an open source database of discovered extrasolar planets), exoplanets have been detected in 131 binary star systems (a majority with only one exoplanet, but two star systems with five planets), 23 triple star systems (including one star

system with seven planets) and 2 quadruple star systems. It's only a matter of time before Asimov's setting for his fictional story is found among the multitude of stars in the Milky Way.

The constellation Gemini is high in the evening sky this time of year, to the east and not far from Orion. Castor is the second brightest star in the constellation (Pollux is the brightest). While appearing as a single star to the eye, Castor is a multiple star system. The system contains three pairs of binary stars orbiting a common center, approximately 49 light years from Earth. The stars range in mass from 2.15 times our Sun (Castor Aa) to 40% to 60% of our Sun's mass (Castor Ab and Bb). At this time, no planets have been detected within the system.



Twist of Fate

On March 3, 1969, a Saturn V rocket carried the crew of Apollo 9 into Earth orbit for the first manned flight test of the lunar module. The ten-day mission was the most complex conducted with two manned spacecraft, including the evaluation and testing of the first spacecraft designed to operate solely outside the Earth's atmosphere, a spacewalk, rendezvous and docking exercises, and the test firing of the lunar module's descent engine. The successes of Apollo 9 paved the way for the lunar landing missions that followed.

A year earlier, the crew of Apollo 9 (astronauts James McDivitt, David Scott and Russell Schweickart) had been assigned to Apollo 8, with the same mission objectives. However, by mid-year 1968, it was clear that the lunar lander, due to numerous manufacturing and technical concerns, would not be ready for a year-end flight. With a growing concern that the Soviets were ready to begin flying their new Soyuz spacecraft again (after a fatal accident on its first flight), NASA decided to send Apollo 8 on a flight around the

A fish-eye camera view of the interior of the Apollo Lunar Module Mission Simulator at the Kennedy Space Center. In the foreground is mission commander James McDivitt; in background is Russell Schweickart, lunar module pilot. Source: NASA.

Moon without the lunar lander. McDivitt considered the mission no more than a publicity stunt and turned it down, opting to switch with the Apollo 9 crew in anticipation that the lunar lander would then be available for that flight. McDivitt's decision would ultimately determine who would be the first to walk on the Moon, as the backup crew for Apollo 8 would become the prime crew for Apollo 11. With the crew switch, Pete Conrad went from the commander of Apollo 11 to the commander of Apollo 12 and from the first to the third person to walk on the Moon.

March History

On March 16, 1926, in Auburn, Massachusetts, Robert Goddard launched the first liquid fueled rocket on a flight that lasted only 2½ seconds. A graduate of Worcester Polytechnic Institute, despite discharging a powder rocket from the basement of the physics building, the significance of Goddard's feat is compared by space flight historians to the first aircraft flight at Kitty Hawk. Among his achievements, Goddard was first to prove that rockets would work in a vacuum and to mathematically explore the practicality of using rocket propulsion to reach high altitudes and even the Moon (1912). While he was eventually banished from the fields of Auburn by the fire marshal, the site is commemorated by markers on what is now the Pakachoag Golf Course. The next time you are driving on the Massachusetts Turnpike towards Boston and points north, look to your left as you pass Exit 10. Just beyond the large shopping mall is where history was made.

Credit: NASA photo showing Dr. Goddard with his a liquid oxygen-gasoline

More March History

Caroline Herschel was born in Hanover, Germany on March 16, 1750, the fifth of six children. Her four brothers were brought up to be musicians like their father, a talented musician and bandmaster. Caroline's mother saw no need for a girl to be educated and preferred that Caroline become a house servant to the rest of the family. Unfortunately, Caroline contracted typhus at age 10. It permanently stunted her growth (she was just over four feet tall as an adult), further convincing her mother that she wouldn't amount to much.

Caroline's brother William escaped to England during the French occupation of Hanover in 1757. Her father Isaac, who had left to fight the French, returned home in poor health. Caroline lived at home as a servant until his death in 1767. Against her mother's will, she then left Hanover to join her brother William in England.

William Herschel was an accomplished musician although he gained considerable fame with his hobby as an astronomer and telescope maker. His reputation as a craftsman allowed him to quit his job as a musician and concentrate on astronomy. Caroline became her brother's apprentice, helping him design and build larger and more powerful telescopes. She also assisted her brother in recording his observations, sitting in a window and writing by candlelight while her brother called out what he saw through the telescope's eyepiece.

Astronomy became a full-time occupation when William discovered the planet Uranus in 1781 and received an annual endowment from King George III. When her brother was away, Caroline would use her own telescope to sweep the sky looking for comets. On August 1, 1786, Caroline discovered her first comet, the first comet to be discovered by a woman. Between 1786 and 1797 she would discover eight comets, as well as a number of deep sky objects.

With the marriage of William to Mary Pitt in 1788 and the birth of their son John in 1792, Caroline became involved in the education of her nephew. Under his father's and aunt's tutelage, John would become the first astronomer to thoroughly survey the southern hemisphere. Following William's death in 1822, Caroline continued to assist John in his astronomical work.

Caroline catalogued every discovery she and William made. Two of her catalogues are still in use today. She lived to be 98 and was recognized by the King of England, the Royal Astronomical Society, the King of Prussia and the King of Denmark for her life-long scientific achievements. After her death, Caroline Herschel was honored by the astronomical community by the naming of a lunar crater after her (C. Herschel) and an asteroid (281) Lucretia (her middle name).

Zodiacal Light

The solar system is filled with tiny dust particles from the passing of comets and collisions of asteroids. The dust orbits in the same plane as the Earth and the other planets. Shortly before sunrise and just after sunset, sunlight can be seen reflecting off this disk of debris. Called the zodiacal light, it is best observed when the ecliptic (the apparent path of the Sun and planets) is nearly perpendicular to the horizon (on spring evenings and autumn mornings). The best time to glimpse the zodiacal light is when the Moon is absent from the evening sky (for example, between March 1st and the 8th).

March Nights

March, the month named for the planet Mars, denotes the end of the long winter nights. The Sun crosses the celestial equator at 12:30 am (EDT) on the 20th marking the Vernal Equinox and the beginning of the spring season in the northern hemisphere. If you have the opportunity to be in the Yucatan on this day, take a trip out to Chichen Itza to watch the Sun cast the shadow of a plumed serpent on the pyramid of Kukulcan.

Sunrise and Sunset

Sun	Sunrise	Sunset
March 1st (EST)	06:28	17:45
March 15th	07:05	19:01
March 31st	06:38	19:18

Jupiter and its Moons

Jupiter reaches Opposition on March 8th, rising with the setting Sun and visible all night. By the end of March, it will be rising almost 2 hours earlier and well placed in the evening for observers. As one of the brightest star-like objects in the night sky, Jupiter can be found in the constellation Leo.

One of the more interesting and easier events to observe through a telescope is the projection of a shadow from one of Jupiter's moons on the Jovian disk as the moon passes in front of (or transits) the planet. The

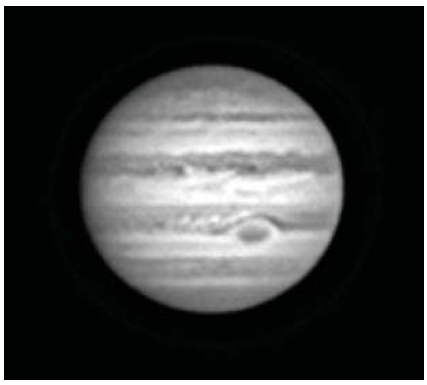


photo above shows the shadow of Ganymede on the Jovian disk. On nights of good visibility the following events should be visible through a moderately-sized telescope.

Jupiter Moon Transits

Date	Moon	Transit Begins	Transit Ends
Feb 29th	Calisto	10:08 pm	1:16 am (1st)
7th	Europa	6:09 pm	8:58 pm
7th	Io	7:28 pm	9:43 pm
14th	Europa	9:46 pm	12:34 am (15th)
14th	Io	10:22 pm	12:37 am (15th)
22nd	Io	12:15 am	2:31 am
22nd	Europa	12:23 am	3:11 am
23rd	Io	6:44 pm	8:59 pm
23rd	Ganymede	7:47 pm	11:05 pm
30th	Io	8:38 pm	10:53 pm
30th	Ganymede	11:47 pm	3:03 am (31st)

Transit of Jupiter's Red Spot

The Red Spot is a large cyclone in the upper Jovian atmosphere. The rapid rotation of this gas giant (10 hours) may be responsible for the longevity of this storm, which has been observed for over 300 years. The Red Spot will cross the center line of the planetary disk on the following evenings during the hours between 7 pm to midnight local time:

Date	Transit Time	Date	Transit Time
Feb 29th	10:19 pm	17th	10:18 pm
3rd	7:48 pm	19th	11:56 pm
5th	9:26 pm	22nd	9:25 pm
7th	11:04 pm	24th	11:03 pm
10th	8:33 pm	27th	8:33 pm
12th	10:11 pm	29th	10:11 pm
15th	8:40 pm		

Astronomical and Historical Events

1st Last Quarter Moon
1st U.S. astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko return to Earth after a one-year stay on the International Space Station
1st Aten Asteroid 2011 EH17 near-Earth flyby (0.028 AU)
1st Kuiper Belt Object 2013 FZ27 at Opposition (47.770 AU)
1st History: Soviet spacecraft Venera 13 lands on Venus and records first color panoramic views of the surface (1982)
1st History: discovery of Saturn's moon *Helene* by Pierre Laques and Jean Lecacheux from the Pic du Midi Observatory in the French Pyrenees; named after Helen of Troy (1980)
1st History: Soviet spacecraft Venera 3 lands (crashes) on Venus, becoming first spacecraft to impact the surface of another planet (1966)
2nd Atira Asteroid 2015 DR215 near-Earth flyby (0.071 AU)
2nd History: launch of the Rosetta spacecraft (2004); rendezvoused with Comet 67 P/Churyumov-Gerasimenko in May 2014, sending a lander to its surface in November 2014
2nd History: launch of Pioneer 10, a Jupiter flyby mission (1972)
3rd History: Chinese National Space Agency announces the Chang'e lunar exploration program (2003)
3rd History: launch of Apollo 9 with astronauts James McDivitt, David Scott and Russell Schweikart in the first manned flight test of the lunar module (1969)
3rd History: launch of the Pioneer 4 spacecraft towards the Moon; first U.S. spacecraft to escape the Earth's gravity (1959)
4th Apollo Asteroid 2015 TJ1 near-Earth flyby (0.060 AU)
4th Apollo Asteroid 2015 WH2 near-Earth flyby (0.079 AU)
5th Apollo Asteroid 2013 TX68 near-Earth flyby (0.003 AU)
5th History: Soviet spacecraft Venera 14 lands on Venus and uses a screw drill to obtain a surface sample that was determined to be similar to oceanic basalts on Earth (1982)
5th History: flyby of Jupiter by the Voyager 1 spacecraft (1979)
6th Amor Asteroid 3552 *Don Quixote* closest approach to Earth (4.949 AU)
6th Kuiper Belt Object 2013 FY27 at Opposition (79.177 AU)
6th History: the Dawn spacecraft enters orbit around the dwarf planet *Ceres* (2015)
6th History: launch of the Kepler telescope from Cape Canaveral Air Force Station aboard a Delta II rocket (2009); designed to survey nearby stars for Earth-size and smaller planets; as of mid-February 2016 JPL's Planet Quest reports 1,941 confirmed exoplanets orbiting 1,209 stars
6th History: flyby of Comet Halley by Vega 1, a Soviet spacecraft (1986)
7th Apollo Asteroid 2007 DM41 near-Earth flyby (0.083 AU)
7th History: John Herschel born, first astronomer to survey the southern hemisphere (1792)

8th New Moon
8th Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
8th Jupiter at Opposition, rising with the setting Sun and visible all night
8th History: maiden voyage of Europe's first unmanned cargo ship to the International Space Station; the Jules Verne was launched from Kourou, French Guiana aboard an Ariane 5 rocket; in addition to delivering supplies to the ISS, the cargo ship contained a manuscript by the 19th century French author and science fiction pioneer with computations of distances from Earth to several astronomical destinations, as well as to the center of the planet (2008)
8th History: flyby of Comet Halley by Susei, a Japanese spacecraft (1986)
8th History: discovery of rings around Uranus by NASA's airborne observatory (1977)
9th History: Space Shuttle Discovery (STS-133) makes its final landing (2011)
9th History: flyby of Comet Halley by Vega 2, a Soviet spacecraft (1986)
9th History: launch of the Soviet spacecraft Sputnik 9, with dog Chernushka (1961)
9th History: Yuri Gagarin born; first person to orbit the Earth in 1961 (1934)
10th Moon at perigee (closest distance from Earth)
10th History: Mars Reconnaissance Orbiter arrives at Mars (2006)
10th History: flyby of Comet Halley by Sakigake, a Japanese spacecraft (1986)

Astronomical and Historical Events (continued)

11th History: launch of Pioneer 5 into solar orbit between the Earth and Venus; confirmed the existence of interplanetary magnetic fields (1965)
11th History: Urbain Leverrier born, mathematician and astronomer, predicted existence of Neptune (1811)
12th **Second Saturday Stars - Open House at McCarthy Observatory**
13th Daylight Saving - Set Clock Ahead 1 Hour (United States)
13th History: flyby of Comet Halley by Giotto, a European Space Agency spacecraft (1986)
13th History: discovery of Saturn's moon *Calypso* by Dan Pascu, P.K. Seidelmann, William Baum and D. Currie (1980)
13th History: Percival Lowell born, established observatory in Flagstaff, AZ to observe Schiaparelli's Martian "canali" and look for other signs of life (1855)
13th History: William Herschel discovers the planet Uranus; originally named Georgium Sidus by Herschel in honor of his patron, King George III of England (1781)
14th Scheduled launch of ESA's ExoMars Trace Gas Orbiter and Schiaparelli lander aboard a Russian Proton rocket from the Baikonur Cosmodrome in Kazakhstan
14th History: Stardust passes within 112 miles (181 km) of the nucleus of Comet Tempel 1 (2011)
14th History: John J. McCarthy Observatory issued Observatory Code Number 932 by the Minor Planet Center of the International Astronomical Union (2001)
14th History: first European launch of a liquid-fueled rocket by Johannes Winkler (1931)
14th History: Albert Einstein born, developed theories of mass to energy conversion and the curvature of space and time in large gravitational fields (1879)
14th History: Giovanni Schiaparelli born, director of the Milan Observatory and first to describe faint features on Mars as "canali" (1835)
15th First Quarter Moon
15th Comet 9P/Tempel at Opposition (1.062 AU)
15th Apollo Asteroid 2010 FR near-Earth flyby (0.089 AU)
15th Asteroid *6 Hebe* closest approach to Earth (1.893 AU)
15th History: San Juan Capistrano Meteorite Fall; the largest piece (50.5 g) penetrated the aluminum roof of a carport in a mobile-home park (1973)
16th History: third and final flyby of Mercury by the Mariner 10 spacecraft (the last of the Mariner probes); Mariner 10 was also the first spacecraft to use solar radiation pressure on its solar panels and the antenna for attitude control during flight (1975)

Astronomical and Historical Events (continued)

16th History: launch of Gemini 8 with astronauts Neil Armstrong and David Scott; first docking with another space vehicle, an unmanned Agena stage (1966)
16th History: launch of the first Titan II Intercontinental Ballistic Missile, also used as the launch vehicle for the manned Gemini spacecraft in the early 1960's (1962)
16th History: Robert Goddard launches first liquid-fuel rocket in Auburn, MA (1926)
16th History: Caroline Herschel born (1750)
17th Atira Asteroid 2014 FO47 closest approach to Earth (0.106 AU)
17th History: launch of the Gravity Recovery And Climate Experiment (GRACE) spacecraft (2002)
17th History: launch of Vanguard 1, 4th artificial satellite and oldest still orbiting Earth (1958)
17th History: Galileo Galilei publishes "Sidereus Nuncius" (Starry Messenger), the first scientific treatise based on observations made through a telescope; it described Galileo's early observations of the Moon, the stars, and the moons of Jupiter (1610)
18th Scheduled launch of a Russian Soyuz spacecraft carrying the next Expedition crew to the International Space Station from the Baikonur Cosmodrome, Kazakhstan
18th History: MESSENGER enters orbit around Mercury (2011)
18th History: New Horizons spacecraft (on its way to Pluto) crosses the orbit of Uranus (2011)
18th History: explosion during launch of a Vostok rocket carrying a military spy satellite kills 48 members of the Soviet Missile Troop; likely cause of explosion was an oxygen peroxide leak caused by the poor quality of the rocket's fuel filters (1980)
18th History: Alexei Leonov performs first spacewalk from Soviet Voskhod spacecraft (1965)
19th Apollo Asteroid 2010 FX9 near-Earth flyby (0.018 AU)
19th Neptune Trojan 316179 (2010 EN65) at Opposition (24.888 AU)
19th History: flyby of the Moon by the Japanese spacecraft Hiten (1990)
19th History: Tenham meteorite fall; fragments of a large meteor rain down on a remote area of western Queensland, Australia (1879)
19th History: Moon flyby by the Hiten spacecraft; Japan's first lunar flyby, orbiter and surface impactor (1990)
20th Vernal Equinox (beginning of the Spring season in the northern hemisphere) at 12:30 am EDT
20th Scheduled launch of an Orbital Sciences Cygnus cargo-carrying spacecraft to the International Space Station from the Cape Canaveral Air Force Station, Florida
21st History: launch of Ranger 9, Moon impact mission; transmitted the highest resolution imagery obtained to that date before impacting the floor of Alphonsus crater on the 24th (1965)
22nd Dwarf Planet 136472 Makemake at Opposition (51.568 AU); discovered on March 31, 2005 by Michael E. Brown, Chad Trujillo and David Rabinowitz
22nd Apollo Asteroid 2016 BA14 near-Earth flyby (0.025 AU)
22nd History: launch of space shuttle Atlantis (STS-76), third mission to Russian space station Mir and transfer of the first American woman, Shannon Lucid, to the station (1996)
23rd Full Moon (Full Worm Moon)
23rd History: launch of Gemini 3 with astronauts Virgil Grissom and John Young, first manned Gemini flight (1965)
23rd History: Wernher von Braun born, German rocket scientist and leader of the U.S. moon program (1912)
23rd History: American astronomer J.W. Draper takes first photograph of the Moon (1840)
25th Moon at apogee (furthest distance from Earth)
25th Apollo Asteroid 1994 UG near-Earth flyby (0.044 AU)
25th History: launch of the IMAGE spacecraft, first mission dedicated to mapping the Earth's magnetosphere (2000)
25th History: close approach of Comet Hyakutake (0.10 AU) to Earth (1996)
25th History: launch of Soviet spacecraft Sputnik 10 with dog Zvezdochka (1961)
25th History: Christiaan Huygens discovers *Titan*, Saturn's largest moon (1655)
26th History: John Draper takes first photograph of the Moon (1840)

Astronomical and Historical Events (continued)

27th History: U.S. astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko arrive at the International Space Station for a year-long mission (2015)
27th Aten Asteroid 325102 (2008 EY5) near-Earth flyby (0.098 AU)
27th Apollo Asteroid *1863 Antinous* closest approach to Earth (0.237 AU)
27th History: launch of the Soviet atmospheric probe and lander Venera 8 to Venus (1972)
27th History: launch of Mariner 7, Mars flyby mission (1969)
27th History: President Eisenhower approves the military lunar program to be managed by the Advanced Research Projects Agency (1958)
28th History: flyby of Comet Halley by the ICE spacecraft (1986)
28th History: Heinrich Olbers discovers the asteroid 2 *Pallas* (1802)
29th Apollo Asteroid *2101 Adonis* closest approach to Earth (1.981 AU)
29th History: First flyby of Mercury by the Mariner 10 spacecraft (1974)
29th History: Heinrich Olbers discovers the asteroid 4 *Vesta* (1807)
30th Aten Asteroid 2016 BC14 near-Earth flyby (0.025 AU)
30th Aten Asteroid 2010 GD35 near-Earth flyby (0.039 AU)
30th Aten Asteroid 2008 BX2 near-Earth flyby (0.049 AU)
31st Last Quarter Moon
31st Scheduled launch of a Russian Progress cargo-carrying spacecraft to the International Space Station from the Baikonur Cosmodrome, Kazakhstan
31st History: launch of Soviet spacecraft Luna 10, first man-made object to go into orbit around another planetary body; detected evidence of mass concentrations on the Moon called "mascons" (1966)

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
- **Oppositio**n: 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 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.

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

Photo, Page 3

Venus, low in the southeast, was joined by Mercury rising just before sunrise. A waning crescent Moon completed the gathering on the morning of February 6th, as seen from a snowy ridge in Bridgewater, CT.

For a few weeks in late January and early February, all five of the classical planets were visible in the early morning sky an hour before sunrise. Not shown in the cover photo was Jupiter shining bright and high in the southwestern sky, Mars was almost due south with Saturn to the east near Antares.

Photographer: Bill Cloutier

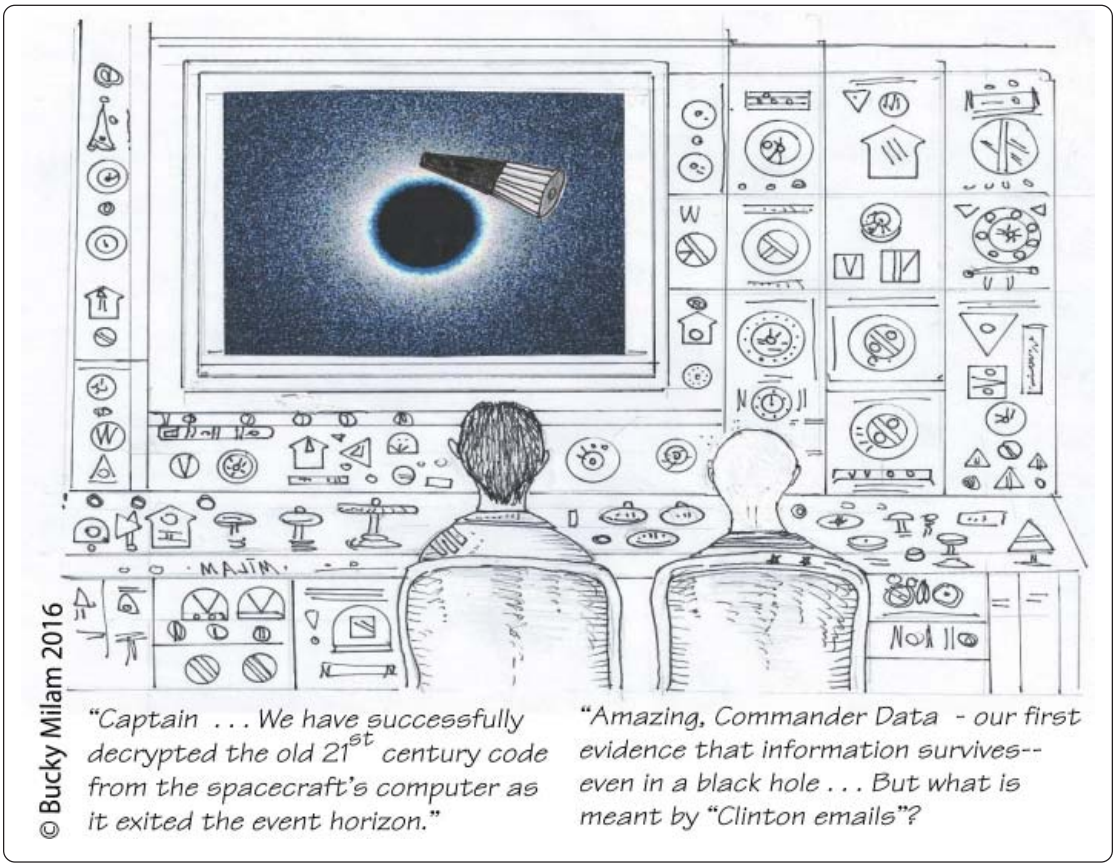
Image Credits

Front page design and graphic calendars: Allan Ostergren

Second Saturday Stars poster: Marc Polansky

Cartoon: Bucky Milam, Danbury Area Computer Society

All other non-credited photos were taken by the author: Bill Cloutier



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

March 12th

7:00 - 9:00 pm

Live from Pasadena, California

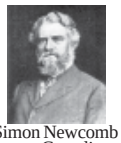
Robotic Exploration of the Solar System

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

Map

March 2016

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Feb 2016 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29		**1**  Soviet spacecraft Venera 3 crashes on Venus (1966) Venera 13 makes successful landing (1982)  Saturn's moon Helene discovered by Pierre Laques and Jean Lecheux (1980)	**2** Launch of Pioneer 10 Jupiter flyby mission (1972)   Launch of Rosetta spacecraft to comet 67 P/ Churyumov-Gerasimenko (2004)	**3**  Launch of Apollo 9; first test of lunar module (1969) ESA's Mars Express spacecraft close flyby of Martian moon Phobos (2010) 	**4**  Giovanni Schiaparelli, born, first to describe Martian "canali" (1835)	**5**  Soviet spacecraft Venera 14 lands on Venus (1982) Launch of the Air Force's second robotic space plane (X-37B) from the Cape Canaveral Air Force Station   Voyager 1 flyby of Jupiter (1979)
6  Flyby of comet Halley by Soviet Vega 1 spacecraft (1986) Launch of Kepler telescope, to search for exoplanets (2009)   Dawn spacecraft arrives at the dwarf planet Ceres	**7**  John Herschel born, first astronomer to survey southern hemisphere (1792)	**8**  Flyby of Comet Halley by Japanese Suisei spacecraft (1986) Discovery of Uranus' rings by NASA Airborne Observatory (1977)   Maiden voyage of the Jules Verne, Europe's first unmanned cargo ship to International Space station (2008)	**9** Flyby of comet Halley by Vega 2, Soviet spacecraft (1986)   Sputnik 9, with dog Chernushka (1961) Yuri Gagarin born - first to orbit Earth (1934) 	**10**  Moon at perigee (closest distance to Earth)  Flyby of Comet Halley by Japanese Sakigake spacecraft (1986) Mars Reconnaissance Orbiter arrives at Mars (2006) 	**11** Urbain Leverrier born - Predicted existence of Neptune (1811)   Launch of Pioneer 5 into solar orbit to study interplanetary magnetic fields (1965)	**12**  Simon Newcomb born - Canadian-American astronomer, studied planetary motion (1855)  2nd Saturday Stars Open House McCarthy Observatory
13 Daylight Saving Time  Percival Lowell born (1855)  Discovery of Uranus by William Herschel (1781)  Flyby of Comet Halley by ESA spacecraft, Giotto (1986) 	**14** Albert Einstein born (1879)   Giovanni Schiaparelli born, first to observe Martian "canali" (1835) JJMO earns Observatory Code 932 from IAU's Minor Planet Center for tracking of asteroid Geographos (2001) 	**15**  Abbé Nicolas Louis de Lacaille born, French astronomer, catalogued southern hemisphere stars and constellations (1713) San Juan Capistrano Meteorite Fall (1973) 	**16**  Robert Goddard First liquid fuel rocket (1926) First Titan 2 ICBM (1962)   Caroline Herschel born. first woman astronomer (1750)	**17**  Vanguard 1 artificial satellite (1958) Publication of *Sidereus Nuncius* on Galileo's astronomical observations (later taken on 2008 Hubble repair mission) (1610) 	**18** Alexei Leonov First Spacewalk (1965) Soviet Vostok rocket explodes during launch, killing 48 (1980)	**19** Moon flyby by Japan's Hiten orbiter and impactor (1990)
20 Vernal Equinox 6:45 PM EDT	**21** Launch of Ranger 9 Moon impact mission (1965)	**22** Shannon Lucid, first American woman on Russian Space Station (1996)	**23** Launch of Gemini 3 (Grissom, Young) (1965) Wernher von Braun born (1912) First photo of Moon by J.W. Draper (1840)	**24** Planet Pluto (now *dwarf* planet) officially named by Lowell Observatory, on suggestion of Oxford schoolgirl, Venetia Burney (1930)	**25** Moon at apogee (farthest from Earth) Launch of IMAGE spacecraft, first to study Earth's magnetosphere (2000) Comet Hyakutake 1996 Christiaan Huygens, discovers Saturn's moonTitan (1655) 	**26** John Draper takes first photograph of the Moon (1840) French mathematician and discoverer of Neptune, Urban Jean Joseph Le Verrier, proposes existence of a new planet Vulcan within orbit of Mercury (1859)
27 Eisenhower approves military lunar program (1958) Launch of Mariner 7 Mars flyby mission (1969)	**28** Flyby of Halley's Comet by ICE spacecraft (1986)	**29** First flyby of Mercury by the Mariner 10 spacecraft (1974) Heinrich Olbers discovers the asteroid 4 Vesta (1807) 	**30** Bernhard Voldemar Schmidt born - German astronomer and inventor of the Schmidt telescope, known for its high definition and wide field of view (1879)	**31** Launch of Soviet spacecraft Luna 10, first to orbit Moon (1966)	**Phases of the Moon** March 1 March 8 March 15 March 23 March 31