
Exploring the Universe
Part 2
A Hubble Sky Full of Stars (NASA Goddard)

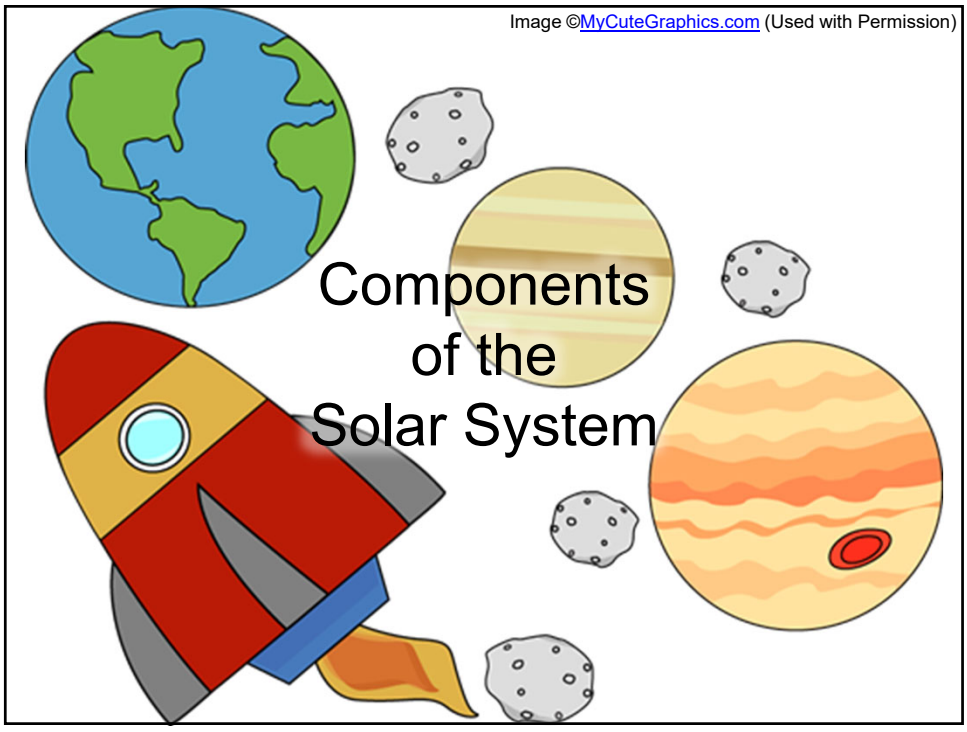


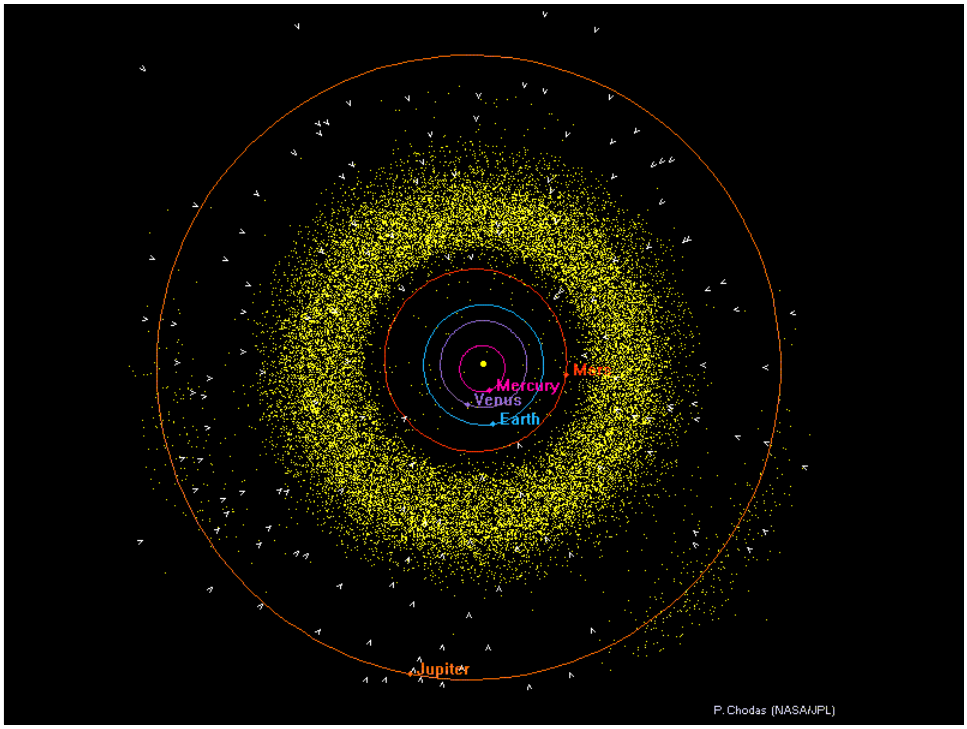
Image ©MyCuteGraphics.com (Used with Permission)
Components of the Solar System

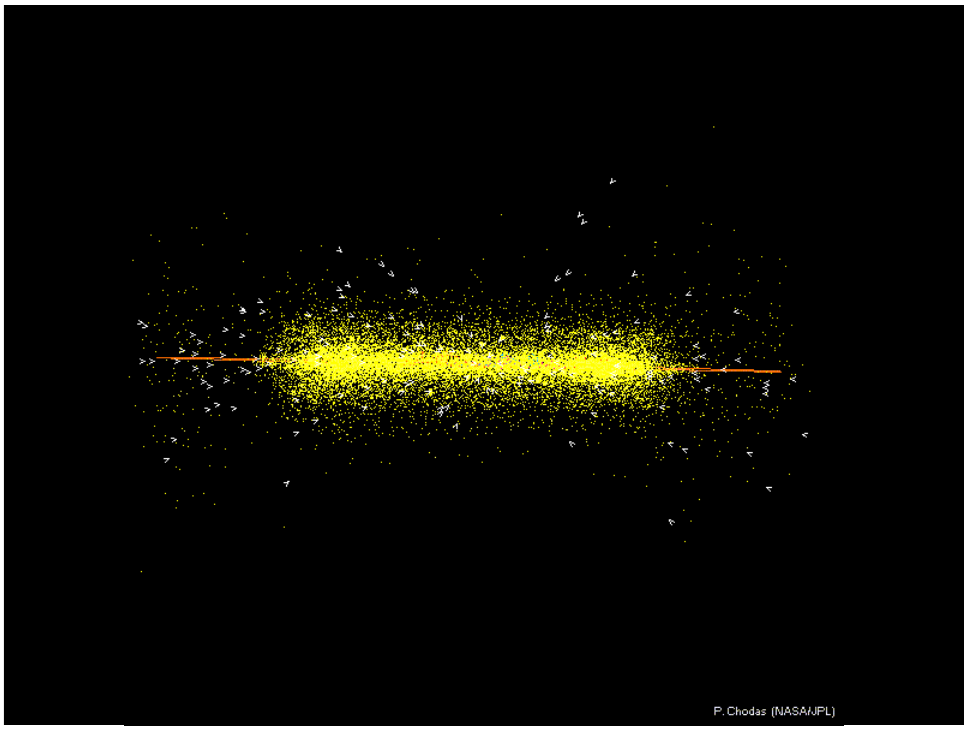
https://youtu.be/OmfAyK6CeIg

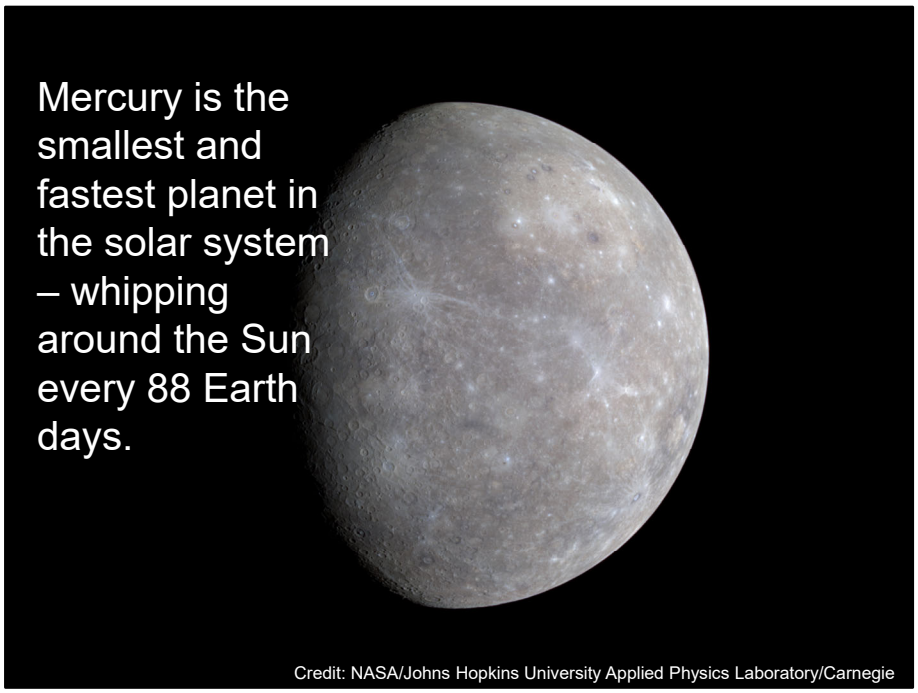
Planet

- The ancient Greeks used the term to refer to stars that wandered across the sky
- Modern definition
  - A celestial body that:
    - is in orbit around the Sun
    - has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape
    - has cleared the neighborhood around its orbit

Credit: NASA's Goddard Space Flight Center/University of Arizona (Public Domain)


Mercury
Venus
Earth
Mars
Jupiter
P. Chodas (NASA/JPL)


P. Chodas (NASA/JPL)



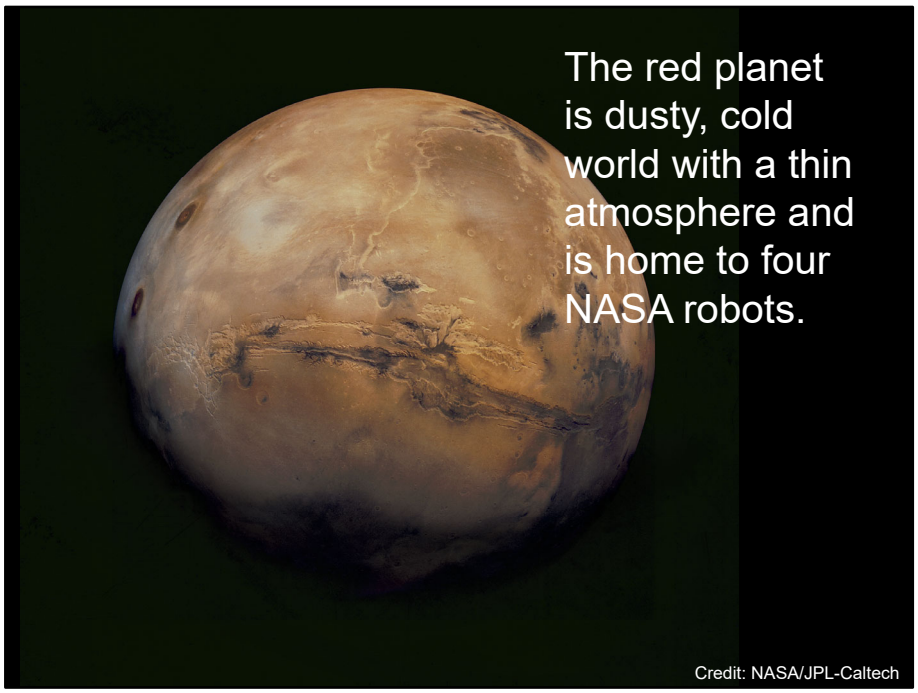
MESSENGER's Wide Angle Camera (WAC), part of the Mercury Dual Imaging System (MDIS), is equipped with 11 narrow-band color filters. As the spacecraft receded from Mercury after making its closest approach on 14 January 2008, the WAC recorded a 3x3 mosaic covering part of the planet not previously seen by spacecraft. The color image shown here was generated by combining the mosaics taken through the WAC filters that transmit light at wavelengths of 1000 nm (infrared), 700 nm (far red), and 430 nm (violet). These three images were placed in the red, green, and blue channels, respectively, to create the visualization presented here. The human eye is sensitive only across the wavelength range from about 400 to 700 nm. Creating a false-color image in this way accentuates color differences on Mercury's surface that cannot be seen in black-and-white (single-color) images.

As it sped away from Venus, NASA's Mariner 10 spacecraft captured this seemingly peaceful view of a planet the size of Earth, wrapped in a dense, global cloud layer. But, contrary to its serene appearance, the clouded globe of Venus is a world of intense heat, crushing atmospheric pressure and clouds of corrosive acid.

This newly processed image revisits the original data with modern image processing software. A contrast-enhanced version of this view, also provided here, makes features in the planet's thick cloud cover visible in greater detail.

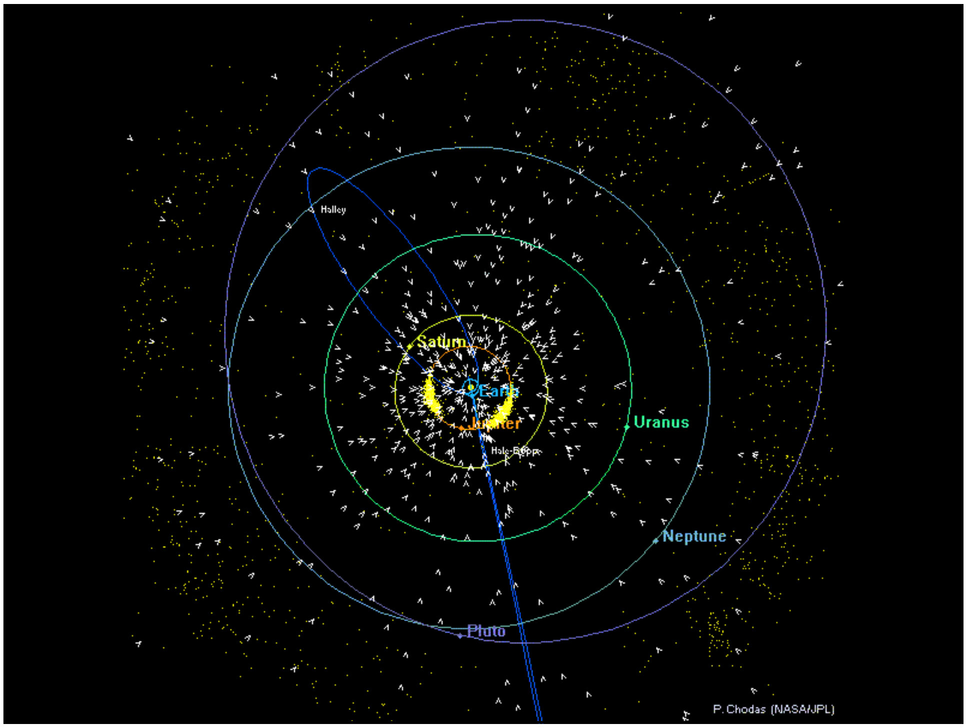
The clouds seen here are located about 40 miles (60 kilometers) above the planet's surface, at altitudes where Earth-like atmospheric pressures and temperatures exist. They are comprised of sulfuric acid particles, as opposed to water droplets or ice crystals, as on Earth. These cloud particles are mostly white in appearance; however, patches of red-tinted clouds also can be seen. This is due to the presence of a mysterious material that absorbs light at blue and ultraviolet wavelengths. Many chemicals have been suggested for this mystery component, from sulfur compounds to even biological materials, but a consensus has yet to be reached among researchers.

The planet Earth on April 17, 2019. The Earth Polychromatic Imaging Camera (EPIC), a NASA camera aboard NOAA's DSCOVR spacecraft, returns daily images of Earth from a distance of nearly 1 million miles (1.6 million kilometers).

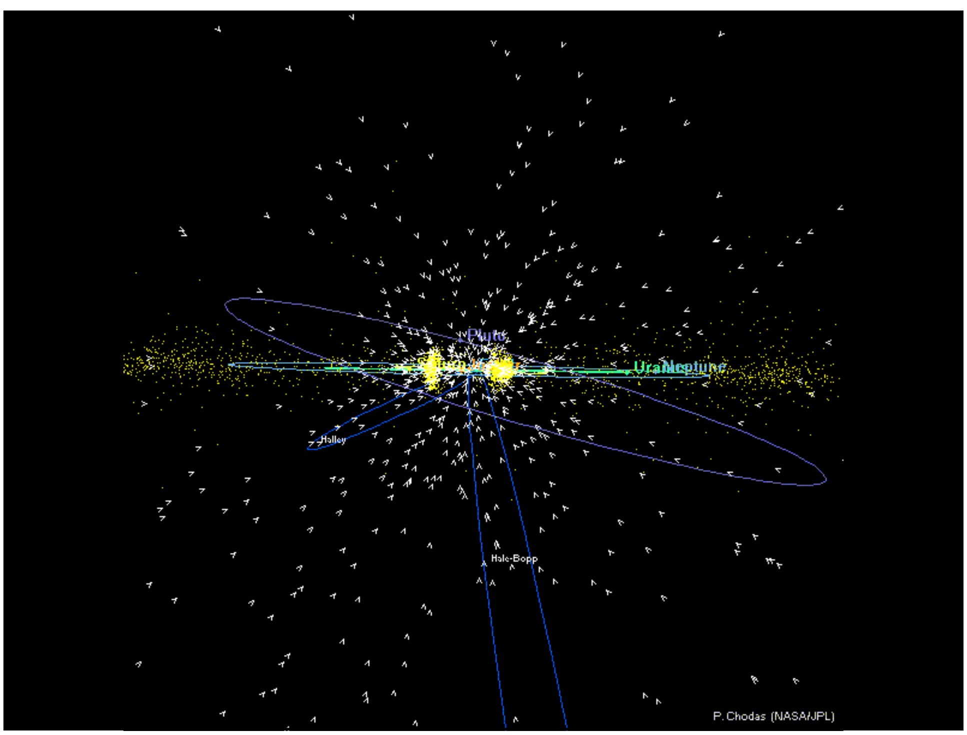


This mosaic of Mars is a compilation of images captured by the Viking Orbiter 1.

The center of the scene shows the entire Valles Marineris canyon system, more than 2,000 miles (3,000 kilometers) long, 370 miles (600 kilometers) wide and 5 miles (8 kilometers) deep, extending from Noctis Labyrinthus, the arcuate system of graben to the west, to the chaotic terrain to the east.


Halley
Saturn
Earth
Jupiter
Hale-Bopp
Uranus
Neptune
Pluto
P. Chodas (NASA/JPL)

35


Pluto
Halley
Hale-Bopp
P. Chodas (NASA/JPL)

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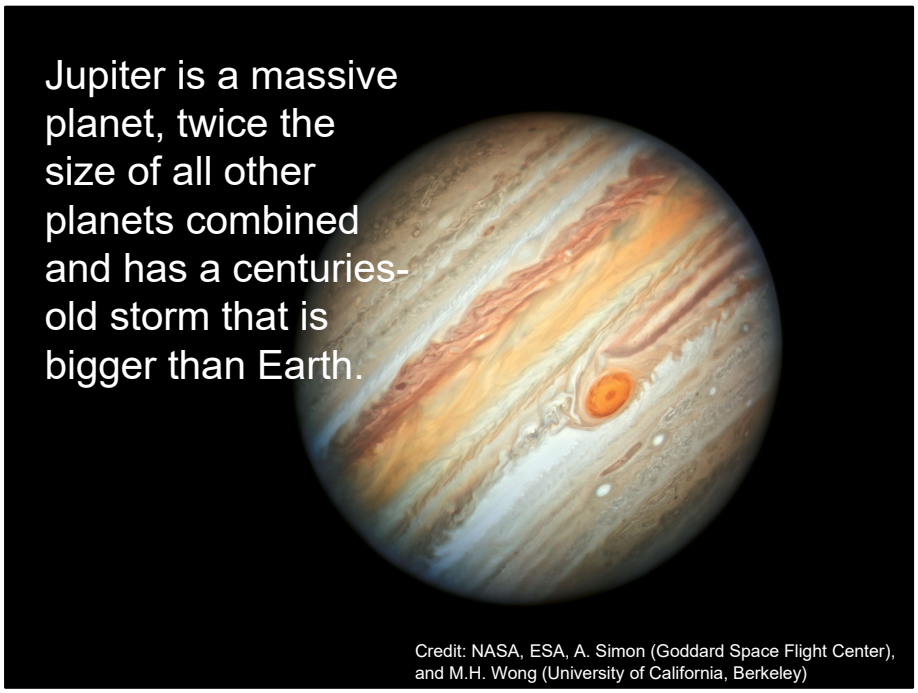
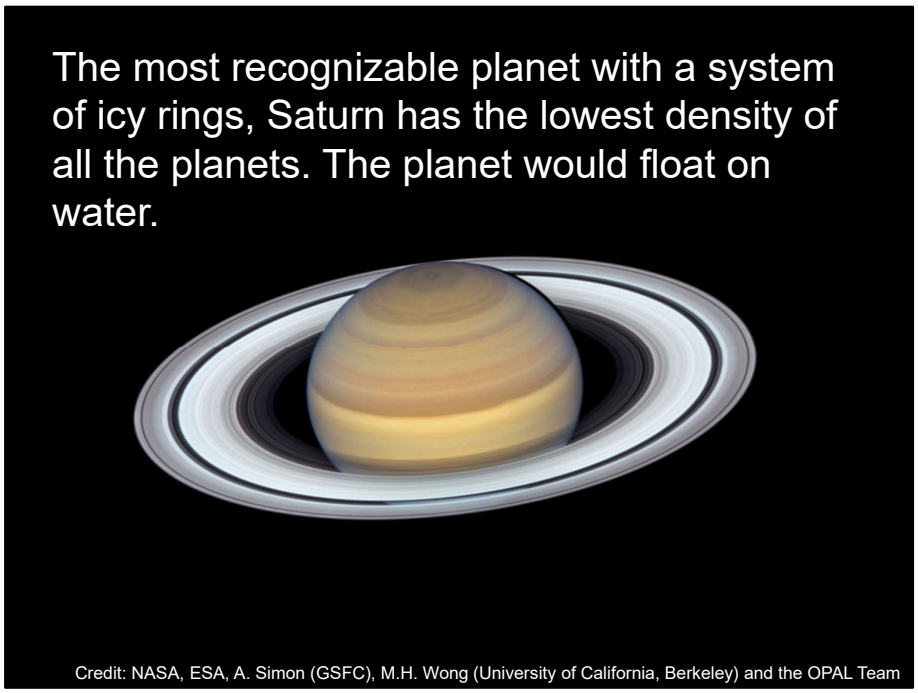


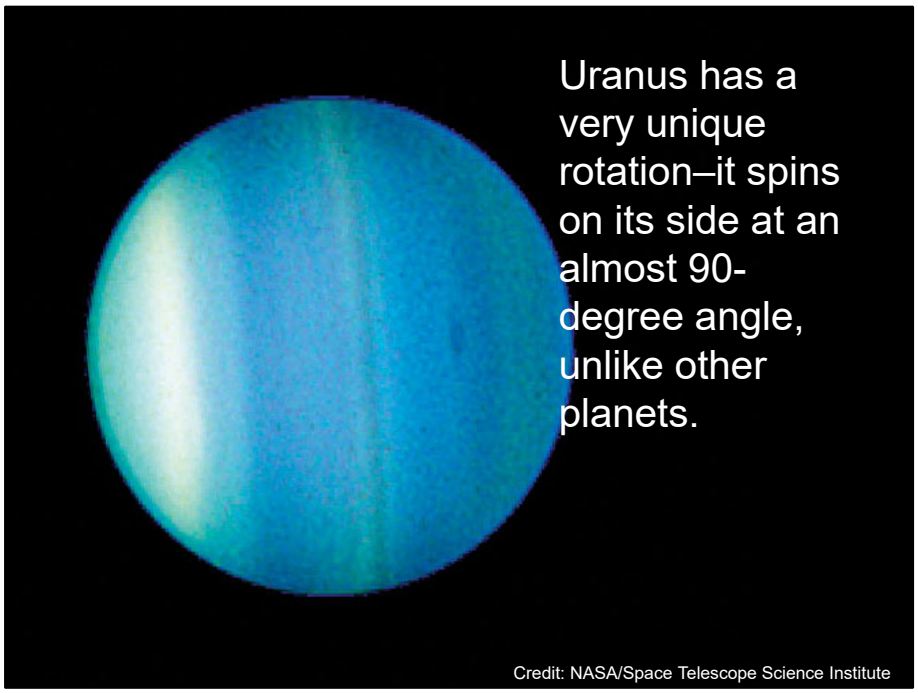
This new Hubble Space Telescope view of Jupiter, taken on June 27, 2019, reveals the giant planet's trademark Great Red Spot, and a more intense color palette in the clouds swirling in Jupiter's turbulent atmosphere than seen in previous years. The colors, and their changes, provide important clues to ongoing processes in Jupiter's atmosphere.

The bands are created by differences in the thickness and height of the ammonia ice clouds. The colorful bands, which flow in opposite directions at various latitudes, result from different atmospheric pressures. Lighter bands rise higher and have thicker clouds than the darker bands.

Among the most striking features in the image are the rich colors of the clouds moving toward the Great Red Spot, a storm rolling counterclockwise between two bands of clouds. These two cloud bands, above and below the Great Red Spot, are moving in opposite directions. The red band above and to the right (northeast) of the Great Red Spot contains clouds moving westward and around the north of the giant tempest. The white clouds to the left (southwest) of the storm are moving eastward to the south of the spot.

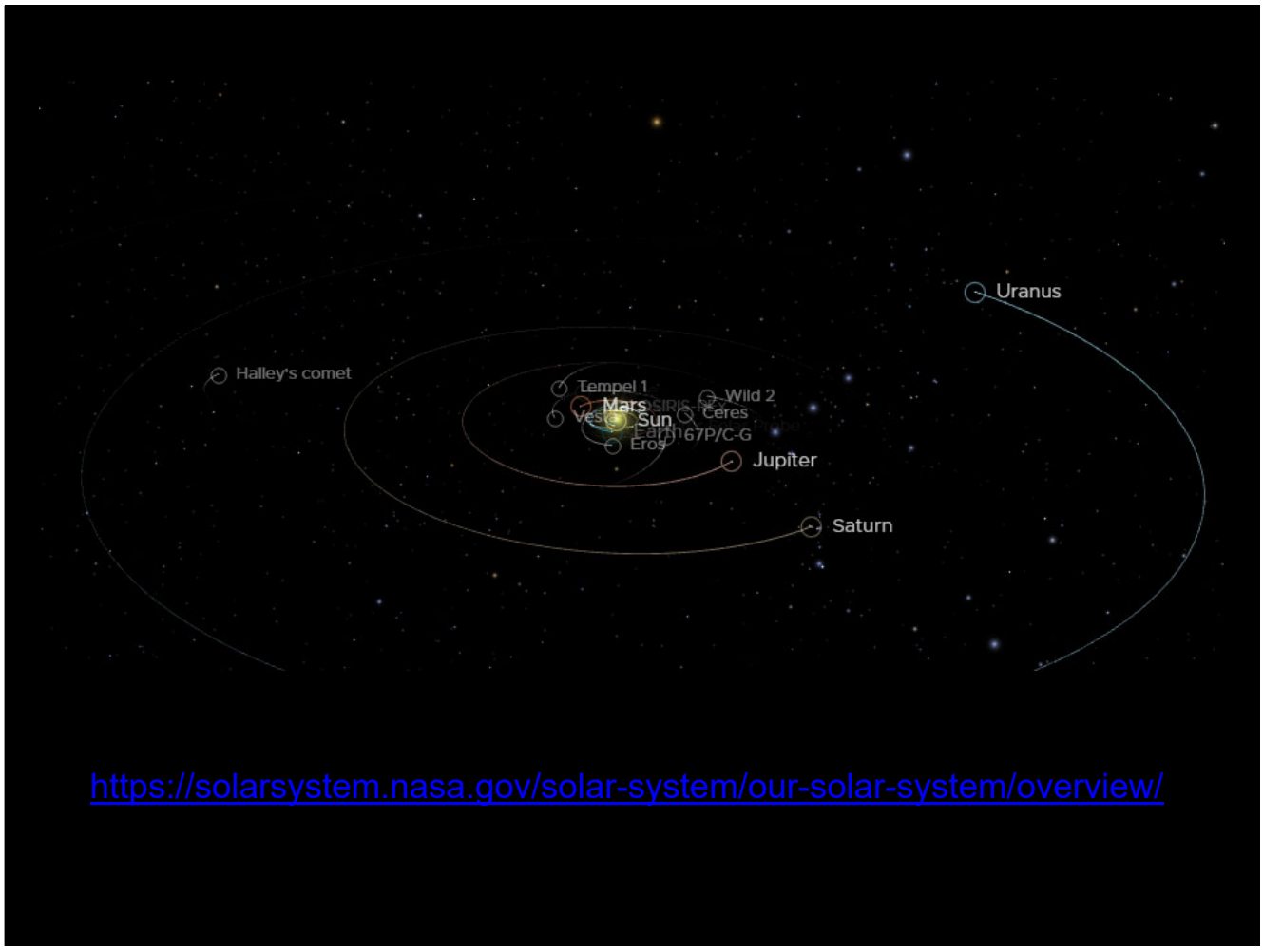


The latest view of Saturn from NASA's Hubble Space Telescope captures exquisite details of the ring system — which looks like a phonograph record with grooves that represent detailed structure within the rings — and atmospheric details that once could only be captured by spacecraft visiting the distant world. Hubble's Wide Field Camera 3 observed Saturn on June 20, 2019, as the planet made its closest approach to Earth, at about 845 million miles away. This image is the second in a yearly series of snapshots taken as part of the Outer Planets Atmospheres Legacy (OPAL) project. OPAL is helping scientists understand the atmospheric dynamics and evolution of our solar system's gas giant planets. In Saturn's case, astronomers will be able to track shifting weather patterns and other changes to identify trends.

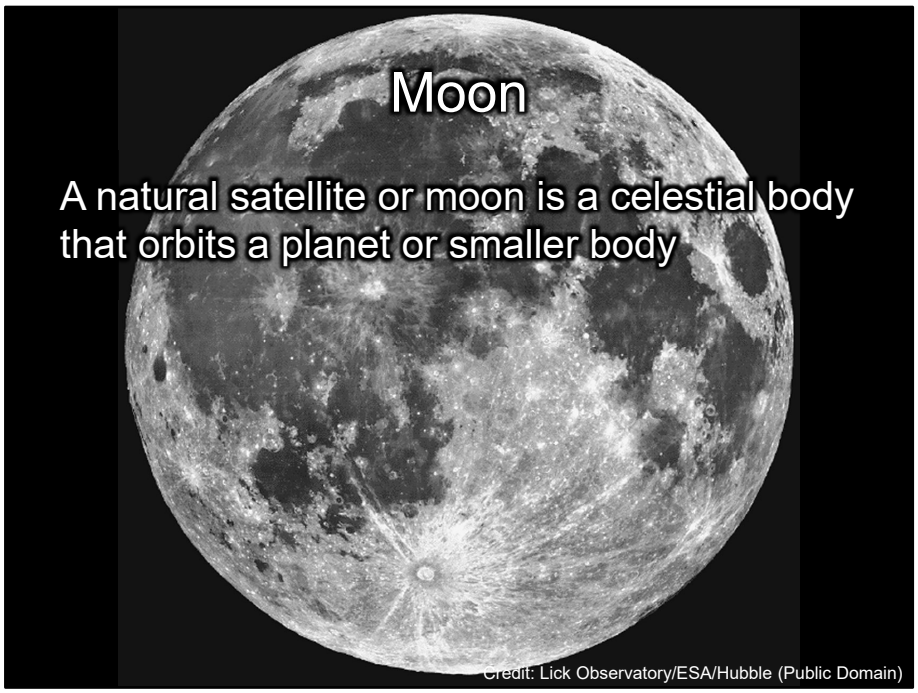


This 2006 image taken by the Hubble Space Telescope shows bands and a new dark spot in Uranus' atmosphere.

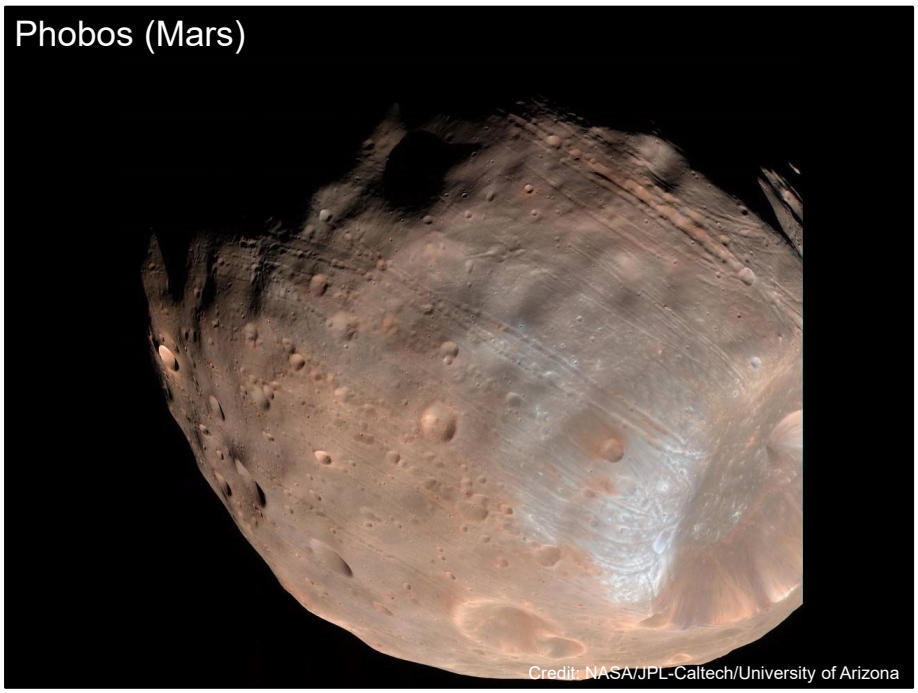
This picture of Neptune was produced from the last whole planet images taken through the green and orange filters on the Voyager 2 narrow angle camera. The images were taken at a range of 4.4 million miles from the planet, 4 days and 20 hours before closest approach. The picture shows the Great Dark Spot and its companion bright smudge; on the west limb the fast moving bright feature called Scooter and the little dark spot are visible. These clouds were seen to persist for as long as Voyager's cameras could resolve them. North of these, a bright cloud band similar to the south polar streak may be seen.



https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/



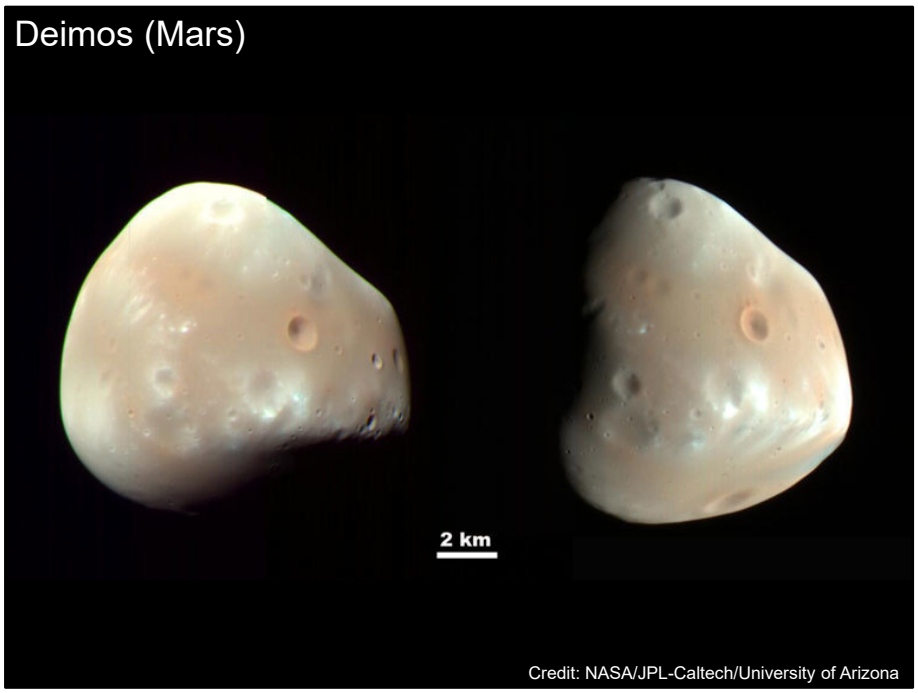
This image from 1991 shows Earth's Moon, with its dark basaltic mare, clearly visible in great detail.



Phobos, gouged and nearly shattered by a giant impact crater and beaten by thousands of meteorite impacts, is on a collision course with Mars.

Phobos is the larger of Mars' two moons and is 17 x 14 x 11 miles (27 by 22 by 18 kilometers) in diameter. It orbits Mars three times a day, and is so close to the planet's surface that in some locations on Mars it cannot always be seen.
Phobos was discovered on Aug. 17, 1877 by Asaph Hall.

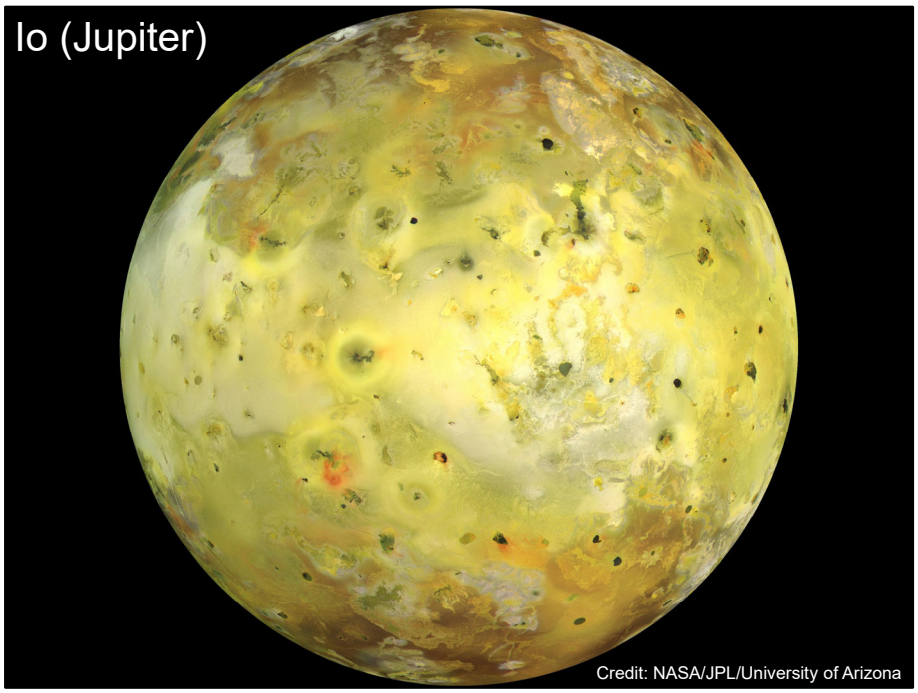
Phobos is nearing Mars at a rate of six feet (1.8 meters) every hundred years; at that rate, it will either crash into Mars in 50 million years or break up into a ring. Its most prominent feature is the 6-mile (9.7 kilometer) crater Stickney, its impact causing streak patterns across the moon's surface. Stickney was seen by Mars Global Surveyor to be filled with fine dust, with evidence of boulders sliding down its sloped surface.



Deimos is the smaller of Mars' two moons. Being only 9 by 7 by 6.8 miles in size (15 by 12 by 11 kilometers), Deimos whirls around Mars every 30 hours.
Like Phobos, Deimos is a small and lumpy, heavily cratered object. Its craters are generally smaller than 1.6 miles (2.5 kilometers) in diameter, however, and it lacks the grooves and ridges seen on Phobos. Typically when a meteorite hits a surface, surface material is thrown up and out of the resulting crater. The material usually falls back to the surface surrounding the crater. However, these ejecta deposits are not seen on Deimos, perhaps because the moon's gravity is so low that the ejecta escaped to space. Material does appear to have moved down slopes. Deimos also has a thick regolith, perhaps as deep as 328 feet (100 meters), formed as meteorites pulverized the surface.

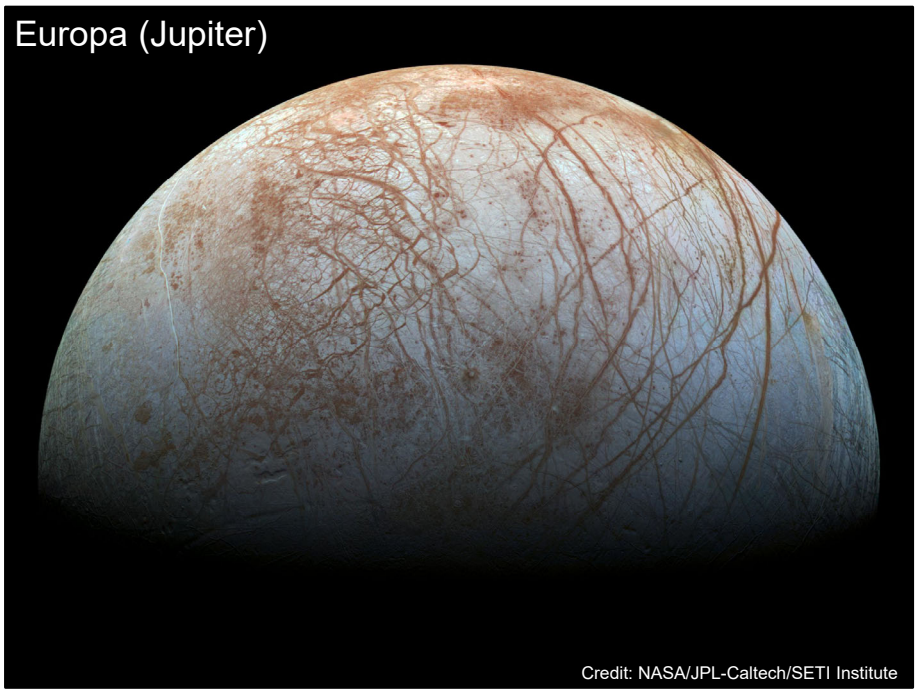
Deimos is a dark body that appears to be composed of C-type surface materials, similar to that of asteroids found in the outer asteroid belt.
Discovery

Deimos was discovered on Aug. 11, 1877 by Asaph Hall.



Jupiter's moon Io is the most volcanically active world in the Solar System, with hundreds of volcanoes, some erupting lava fountains dozens of miles (or kilometers) high. Io is caught in a tug-of-war between Jupiter's massive gravity and the smaller but precisely timed pulls from two neighboring moons that orbit farther from Jupiter—Europa and Ganymede.

NASA's Galileo spacecraft acquired its highest resolution images of Jupiter's moon Io on 3 July 1999 during its closest pass to Io since orbit insertion in late 1995. This color mosaic uses the near-infrared, green and violet filters (slightly more than the visible range) of the spacecraft's camera and approximates what the human eye would see. Most of Io's surface has pastel colors, punctuated by black, brown, green, orange, and red units near the active volcanic centers. A false color version of the mosaic has been created to enhance the contrast of the color variations.

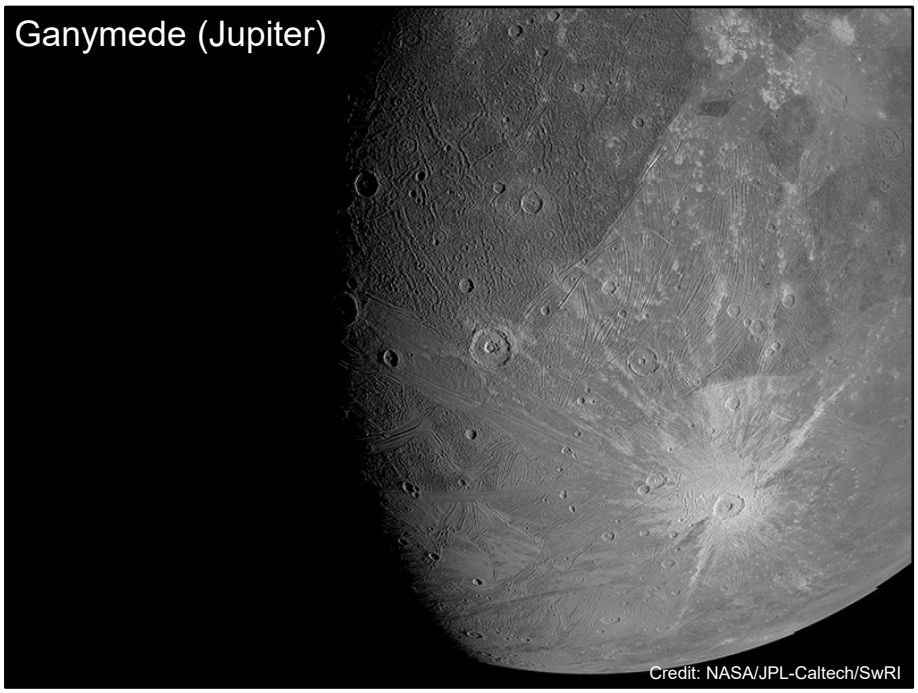


Scientists are almost certain that hidden beneath the icy surface of Europa is a salty-water ocean thought to contain twice as much water as Earth’s oceans combined.

Slightly smaller than Earth's Moon, Europa’s water-ice surface is crisscrossed by long, linear fractures, cracks, ridges, and bands. The moon’s ice shell is probably 10 to 15 miles (15 to 25 kilometers) thick, beneath which the ocean is estimated to be 40 to 100 miles (60 to 150 kilometers) deep. Like Earth, Europa is thought to also contain a rocky mantle and iron core.

The puzzling, fascinating surface of Jupiter's icy moon Europa looms large in this newly-reprocessed color view, made from images taken by NASA's Galileo spacecraft in the late 1990s. This is the color view of Europa from Galileo that shows the largest portion of the moon's surface at the highest resolution.

The view was previously released as a mosaic with lower resolution and strongly enhanced color (see PIA02590). To create this new version, the images were assembled into a realistic color view of the surface that approximates how Europa would appear to the human eye.



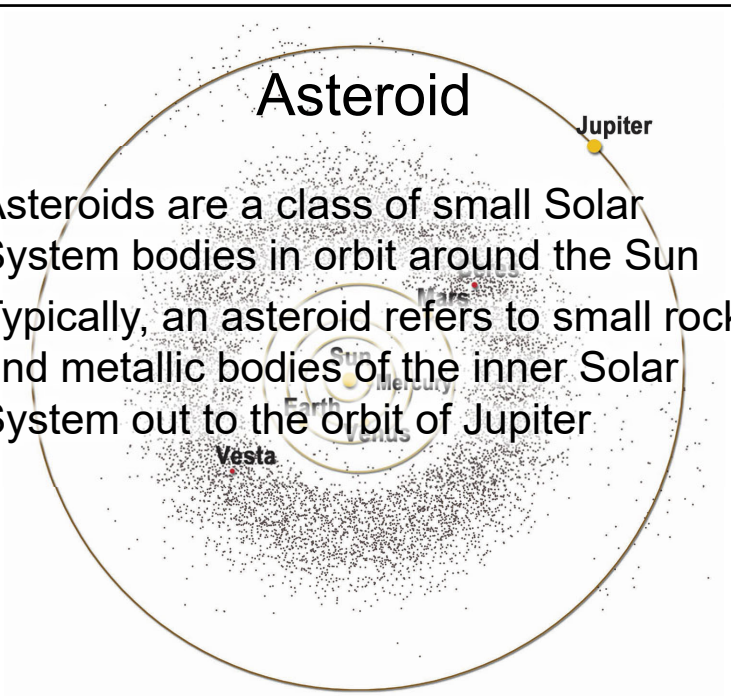
Jupiter's moon Ganymede ("GAN uh meed") is the largest moon in our solar system and the only moon with its own magnetic field. The magnetic field causes auroras, which are ribbons of glowing, electrified gas, in regions circling the moon’s north and south poles. When Jupiter’s magnetic field changes, the aurorae on Ganymede also change, “rocking” back and forth.

Ganymede also has large, bright regions of ridges and grooves that slice across older, darker terrains. These grooved regions are a clue that the moon experienced dramatic upheavals in the distant past.

Ganymede has three main layers. A sphere of metallic iron at the center (the core, which generates a magnetic field), a spherical shell of rock (mantle) surrounding the core, and a spherical shell of mostly ice surrounding the rock shell and the core. The ice shell on the outside is very thick, and about 500 miles (800 kilometers) thick. The surface is the very top of the ice shell. Though it is mostly ice, the ice shell might contain some rock mixed in. Scientists believe there must be a fair amount of rock in the ice near the surface. Ganymede's magnetic field is embedded inside Jupiter's massive magnetosphere.

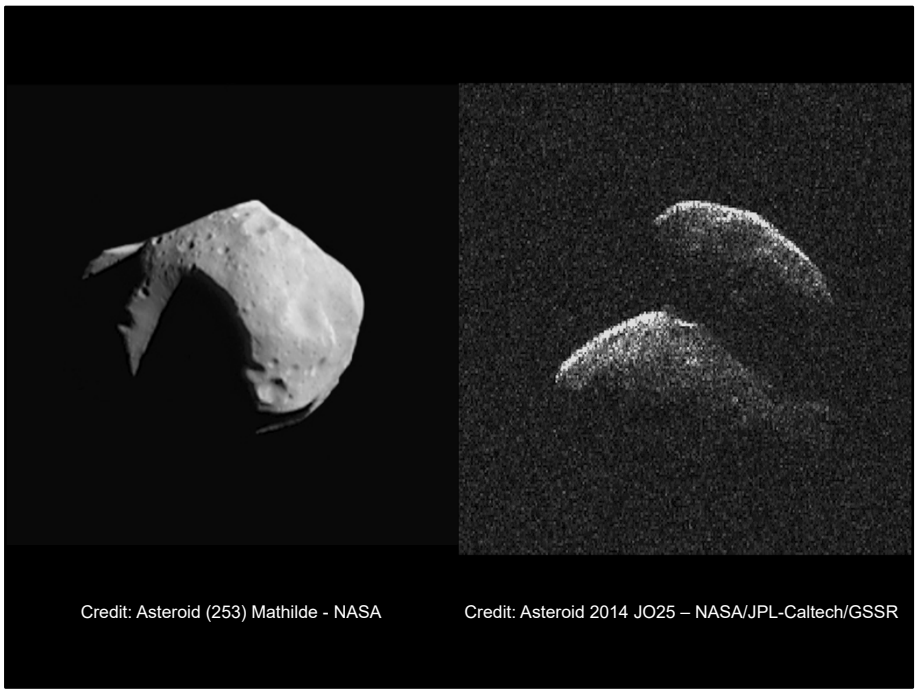
Asteroid

- Asteroids are a class of small Solar System bodies in orbit around the Sun
- Typically, an asteroid refers to small rocky and metallic bodies of the inner Solar System out to the orbit of Jupiter



Credit: Artist's graphic of the asteroid belt – NASA/McREL

https://youtu.be/auxpcdQimCs



Credit: Asteroid (253) Mathilde - NASA

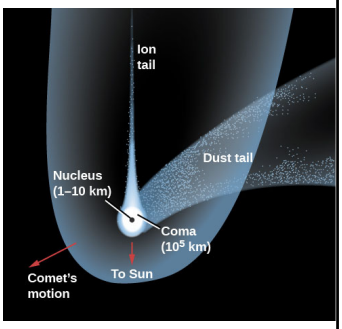
Credit: Asteroid 2014 JO25 – NASA/JPL-Caltech/GSSR

A Photo of Asteroid (253) Mathilde taken by the space probe NEAR Shoemaker on 27 June 1997 from a distance of 2400 km. It is lit up by the sun from the top right. The part of the Asteroid visible in the picture has Dimensions of 59 km x 47 km, whereas the picture resolution is 380px. On the surface, numerous large craters are visible, like the Large Crater in the Center, named Karoo [1], which is more than 30 km wide. Most of it is shaded in the picture.

This movie of asteroid 2014 JO25 was generated using radar data collected by NASA's 230-foot-wide (70-meter) Deep Space Network antenna at Goldstone, California on April 19, 2017. When the observations began 2014 JO25 was 1.53 million miles (2.47 million kilometers) from Earth. By the time the observations concluded, the asteroid was 1.61 million miles (2.59 million kilometers) away. The asteroid has a contact binary structure -- two lobes connected by a neck-like region. The largest of the asteroid's two lobes is estimated to be 2,000 feet (610 meters) across. Asteroid 2014 JO25 approached to within 1.1 million miles (1.8 million kilometers) of Earth on April 19. There are no future flybys by 2014 JO25 as close as this one for more than 400 years. The resolution of the radar images is about 25 feet (7.5 meters) per pixel. 154 images were used to create the movie shown.

Comet

- A relatively small chunk of icy material (typically a few kilometers across) that develops an atmosphere as it approaches the Sun.
  - Later, there may be a very faint, nebulous tail, extending several million kilometers away from the main body of the comet.



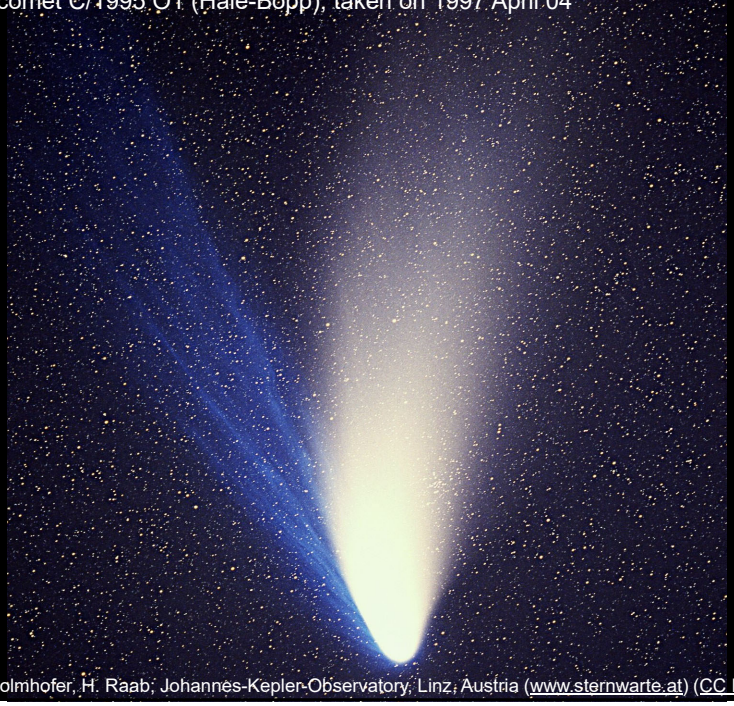
Credit: Astronomy, OpenStax. https://openstax.org/books/astronomy/pages/13-3-the-long-haired-comets. (CC BY 4.0)

https://youtu.be/yB9HHyPpKds

Comet 1P/Halley as taken March 8, 1986, by W. Liller, Easter Island, part of the International Halley Watch (IHW) Large Scale Phenomena Network.

Credit: NASA/W. Liller (Public Domain)

Image of comet C/1995 O1 (Hale-Bopp), taken on 1997 April 04



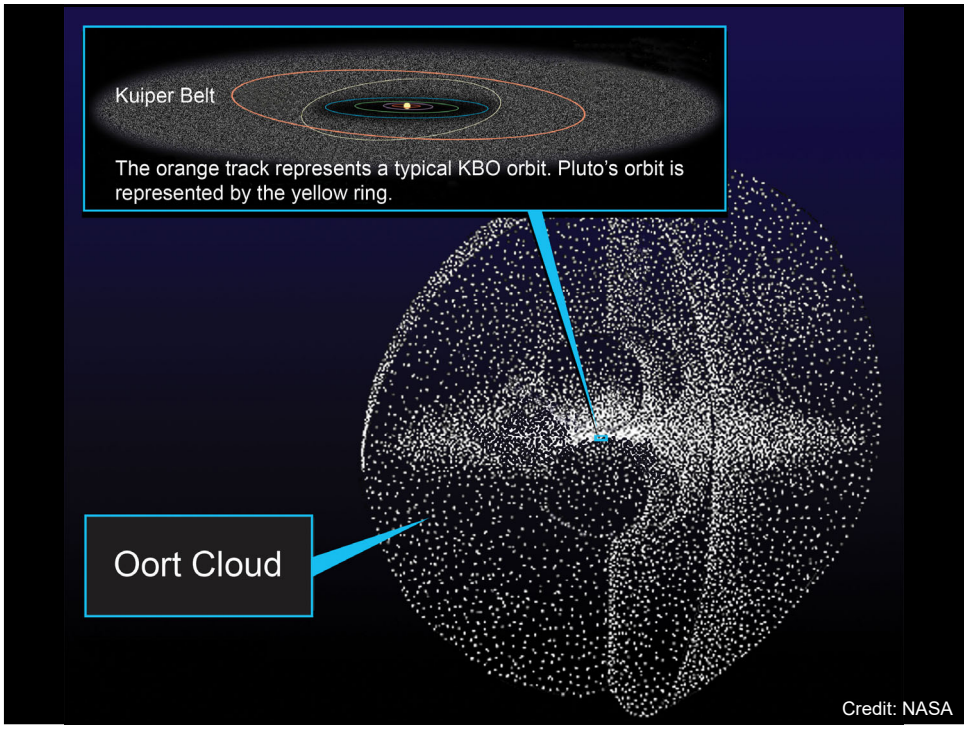
Credit: E. Kolmhofer, H. Raab; Johannes-Kepler-Observatory, Linz, Austria (www.sternwarte.at) (CC BY-SA 3.0)

The Kuiper Belt

- The Kuiper Belt is a donut-shaped region of icy bodies beyond the orbit of Neptune.
- Similar to the asteroid belt, it is a region of leftovers from the solar system's early history.
- It is a source of short period comets.

The Oort Cloud

- The Oort Cloud is the most distant region of our solar system.
- The Oort Cloud is believed to be a giant spherical shell surrounding the rest of the solar system.
- Scientists suspect that the Oort Cloud is the source of most of the long period comets.



https://youtu.be/ZJscxTyI__s

Meteoroids, Meteors, & Meteorites

- **Meteoroids** are objects in space that range in size from dust grains to small asteroids (“space rocks“).
- When meteoroids enter the atmosphere at high speed and burn up, the fireballs or “shooting stars” are called **meteors**.
- When a meteoroid survives a trip through the atmosphere and hits the ground, it’s called a **meteorite**.

https://youtu.be/TuDfZ2Md5x8

The Orionids, which peak during mid-October each year, are considered to be one of the most beautiful showers of the year. Orionid meteors are known for their brightness and for their speed. These meteors are fast—they travel at about 148,000 mph (66 km/s) into the Earth's atmosphere. Fast meteors can leave glowing "trains" (incandescent bits of debris in the wake of the meteor) which last for several seconds to minutes. Fast meteors can also sometimes become fireballs: Look for prolonged explosions of light when viewing the Orionid meteor shower.
The Orionids are also framed by some of the brightest stars in the night sky, which lend a spectacular backdrop for theses showy meteors.

Orionid meteors appear every year around this time when Earth travels through an area of space littered with debris from Halley’s Comet. Credit: NASA/JPL

The Geminids, which peak during mid-December each year, are considered to be one of the best and most reliable annual meteor showers. The Geminids did not start out that way. The Geminids first began appearing in the mid-1800s. However, the first showers were not noteworthy with only 10 - 20 meteors seen per hour. Since that time, the Geminids have grown to become one of the most major showers of the year. During its peak, 120 Geminid meteors can be seen per hour under perfect conditions. The Geminids are bright and fast meteors and tend to be yellow in color.

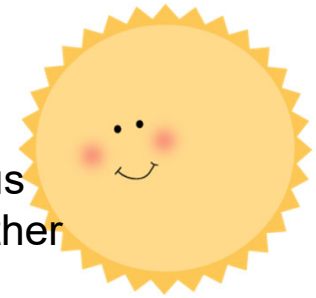
Over 100 meteors are recorded in this composite image taken during the peak of the Geminid meteor shower in 2014. Credit: NASA/MSFC/Danielle Moser, NASA's Meteoroid Environment Office

A composite of all the meteors in an hour. Picture taken August 12, 2016.

Picture taken June 15, 2013.

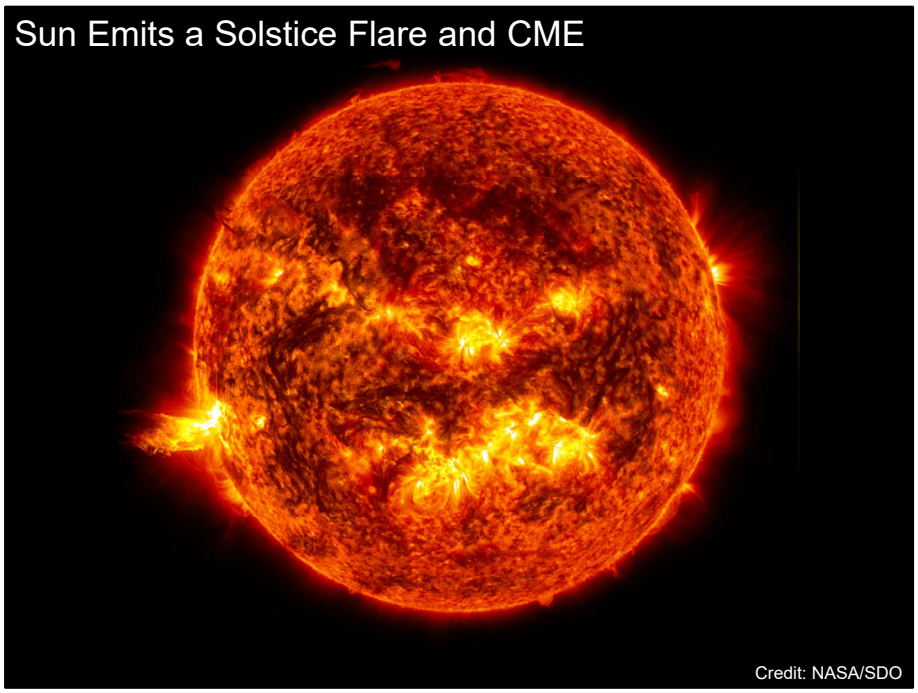
The 1200m diameter, 170m deep Barringer Crater (Meteor Crater) in northern Arizona was created by a 50m wide meteorite about 50000 years ago. Note (for a sense of scale) that the white smudge towards the centre is a large mining compound from various attempts to extract the nickel-iron meteorite remnant. Picture taken April 15, 2010.

Star



- A star is a massive, luminous sphere of plasma held together by gravity.
- The closest star to the Earth is our Sun.
- For part of its life, a star shines due to thermonuclear fusion of hydrogen in its core releasing energy.

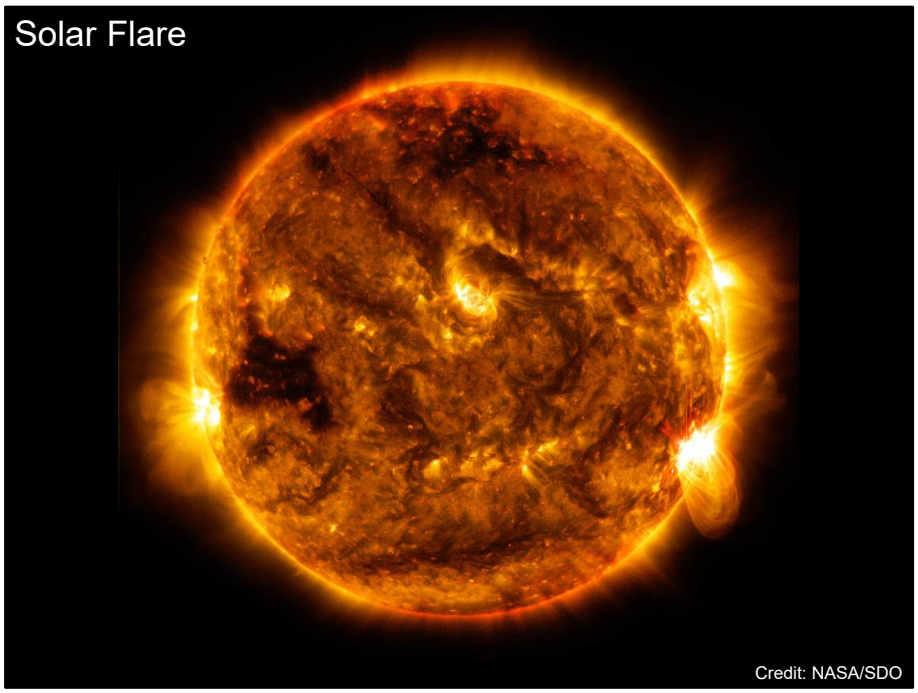
https://youtu.be/ld75W1dz-h0



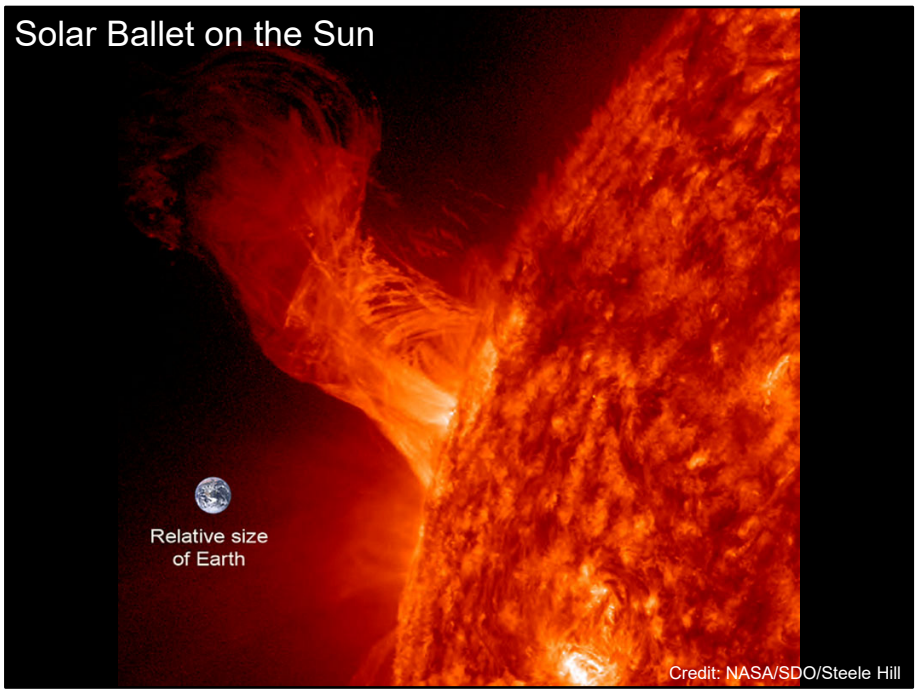
The Sun is a yellow dwarf star, a hot ball of glowing gases. Electric currents in the Sun generate a magnetic field that is carried out through the solar system by the solar wind—a stream of electrically charged gas blowing outward from the Sun in all directions.

This image from June 20, 2013, at 11:15 p.m. EDT shows the bright light of a solar flare on the left side of the Sun and an eruption of solar material shooting through the Sun's atmosphere, called a prominence eruption. The flare was a class M2.9, which is in the low-moderate range. Shortly thereafter, this same region of the Sun sent a coronal mass ejection out into space.

Solar flares are powerful bursts of radiation. Harmful radiation from a flare cannot pass through Earth's atmosphere to physically affect humans on the ground, however -- when intense enough -- they can disturb the atmosphere in the layer where GPS and communications signals travel.



The sun emitted a mid-level solar flare, peaking at 8:13 p.m. EDT on Oct. 1, 2015. NASA's Solar Dynamics Observatory, which watches the sun constantly, captured an image of the event.



The Earth is superimposed on this image to give a sense of the scale. The length of the eruption extends about 160,000 miles out from the Sun. With Earth about 7,900 miles in diameter, this relatively minor eruption is about 20 times the diameter of our planet.

Sunspots

- Sunspots are temporary phenomena on the Sun's photosphere that appear as spots darker than the surrounding areas.
- Sunspots indicate intense magnetic activity.
- Similar phenomena indirectly observed on stars other than the Sun are commonly called starspots.

Sunspots are temporary phenomena on the Sun's photosphere that appear as spots darker than the surrounding areas. They are regions of reduced surface temperature caused by concentrations of magnetic field flux that inhibit convection.

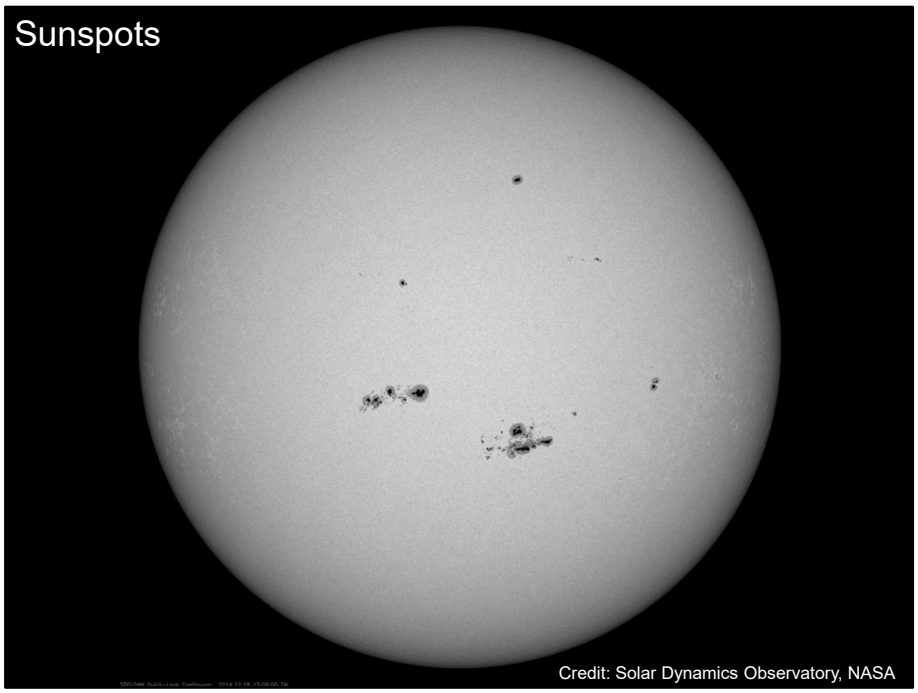
Their number varies according to the approximately 11-year solar cycle.

Larger sunspots can be visible from Earth without the aid of a telescope.

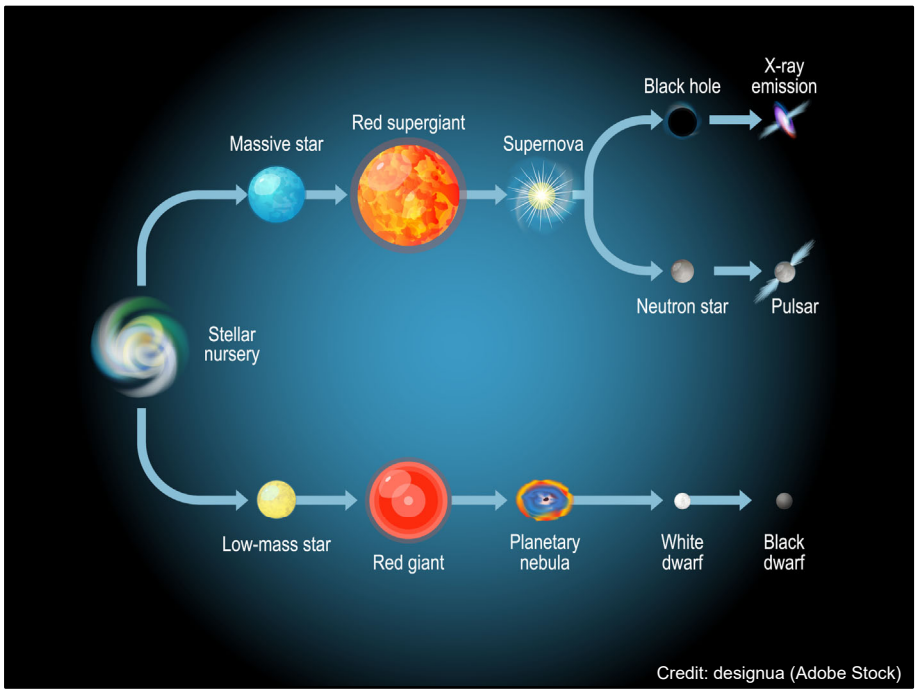
~300 BCE – Greek scholar Theophrastus (student of Plato and Aristotle): first mention of sunspots
1128 – John of Worcester (English monk): first drawings of sunspots
1610 – Thomas Harriot (English), Johannes (son) & David (father) Fabricus (German): first telescopic observation of sunspots

In the early 19th Century, William Herschel was one of the first to equate sunspots with the abundance of heating and cooling it was capable of causing on Earth.

Most solar flares and coronal mass ejections originate in magnetically active regions around visible sunspot groupings.



The physical correlation of magnetic intensity and sunspots is clearly revealed when we fade back and forth between a filtered (i.e., white light) image of the Sun with a magnetic image (magnetogram) taken at the same time (Dec. 18, 2014). Two large sunspot groups with strong magnetic intensity stand out in both the magnetic and white light images. In magnetogram images the stronger black and white areas indicate more powerful polarity. The fading between the two kinds of images helps to underscore the magnetic intensity of sunspots. These two active regions have unleashed a number of flares.



A star's life cycle is determined by its mass. The larger its mass, the shorter its life cycle. A star's mass is determined by the amount of matter that is available in its nebula, the giant cloud of gas and dust from which it was born. Over time, the hydrogen gas in the nebula is pulled together by gravity and it begins to spin. As the gas spins faster, it heats up and becomes as a protostar. Eventually the temperature reaches 15,000,000 degrees and nuclear fusion occurs in the cloud's core. The cloud begins to glow brightly, contracts a little, and becomes stable. It is now a main sequence star and will remain in this stage, shining for millions to billions of years to come.

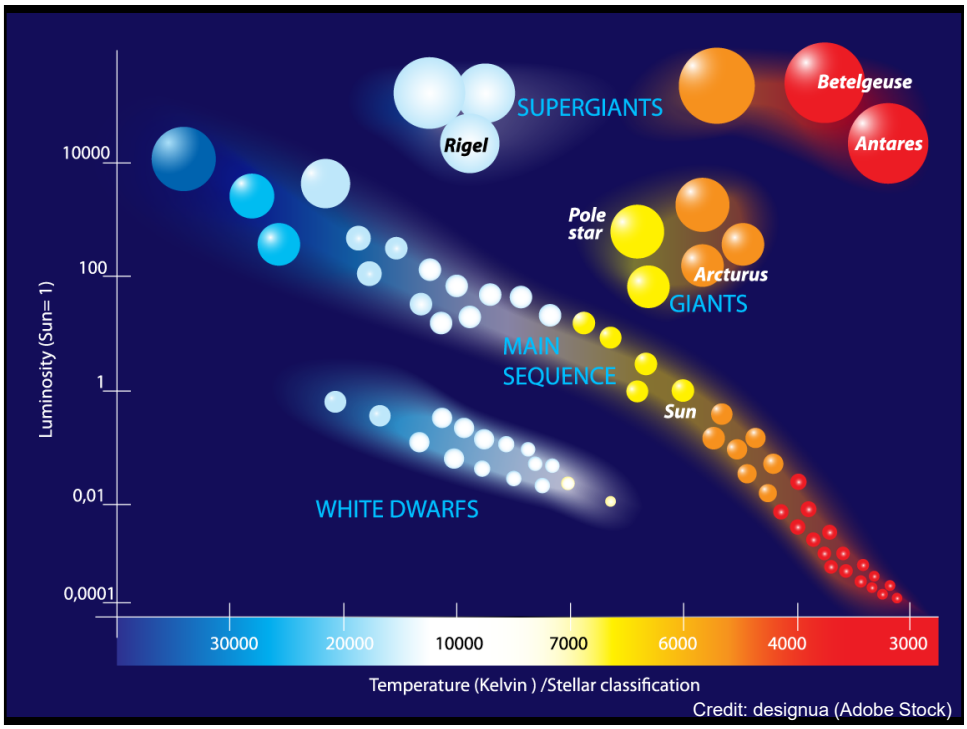
As the main sequence star glows, hydrogen in its core is converted into helium by nuclear fusion. When the hydrogen supply in the core begins to run out, and the star is no longer generating heat by nuclear fusion, the core becomes unstable and contracts. The outer shell of the star, which is still mostly hydrogen, starts to expand. As it expands, it cools and glows red. The star has now reached the red giant phase. It is red because it is cooler than it was in the main sequence star stage, and it is a giant because the outer shell has expanded outward. In the core of the red giant, helium fuses into carbon. All stars evolve the same way up to the red giant phase. The amount of mass a star has determines which of the following life cycle paths it will take from there.

For low-mass stars, after the helium has fused into carbon, the core collapses again. As the core collapses, the outer layers of the star are expelled. A planetary nebula is formed by the outer layers. The core remains as a white dwarf and eventually cools to become a black dwarf.

A massive star (10 times or more the size of our Sun), after the red giant phase, will undergo a supernova explosion. If the remnant of the explosion is 1.4 to about 3 times as massive as our Sun, it will become a neutron star. If the core of a massive star that has more than roughly 3 times the mass of our Sun after the explosion the force of gravity overcomes the nuclear forces which keep protons and neutrons from combining. The core is thus swallowed by its own gravity and becomes a black hole.

Color & Luminosity

- The color of a star is related to its temperature
  - Red stars are at the low temperature end
  - Blue stars are at the high temperature end
- The luminosity of a star is related to its temperature and its size
- The Hertzsprung-Russell (HR) diagram shows the relationship between luminosity, temperature and color.



Nebula

- A nebula is an interstellar cloud of dust, hydrogen gas, helium gas and other ionized gases
- Often considered star-forming regions
  - The formations of gas, dust, and other materials "clump" together to form larger masses, which attract further matter, and eventually will become massive enough to form stars, planets, and other planetary system objects

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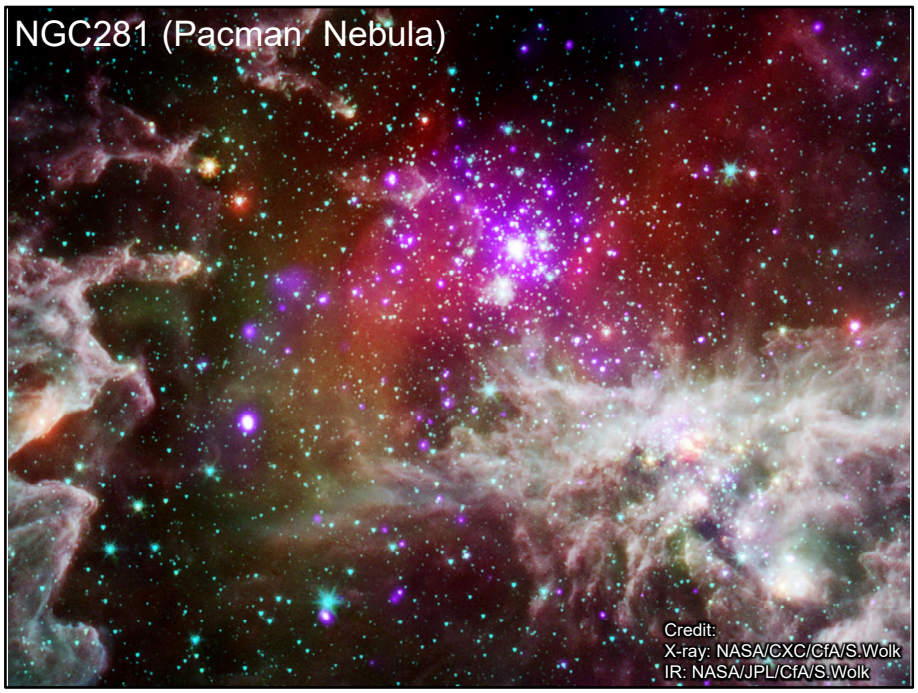
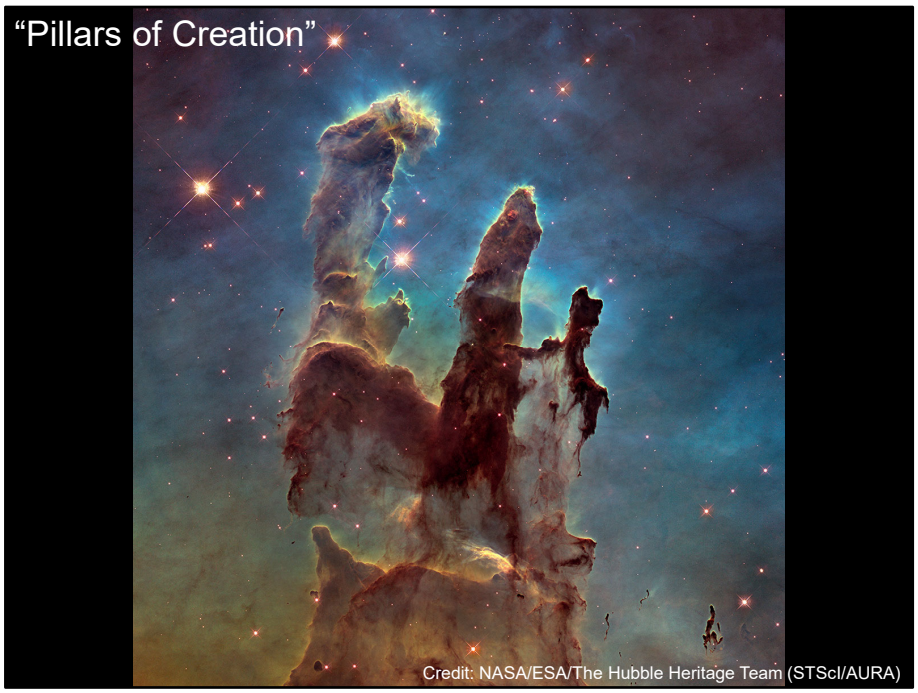


This composite image of NGC 281 contains X-ray data from Chandra, in purple, with infrared observations from Spitzer, in red, green, blue. The high-mass stars in NGC 281 drive many aspects of their galactic environment through powerful winds flowing from their surfaces and intense radiation that creates charged particles by stripping electrons off atoms. The eventual deaths of massive stars as supernovas will also seed the galaxy with material and energy.

NGC 281 is known informally as the "Pacman Nebula" because of its appearance in optical images. In optical images the "mouth" of the Pacman character appears dark because of obscuration by dust and gas, but in the infrared Spitzer image the dust in this region glows brightly.

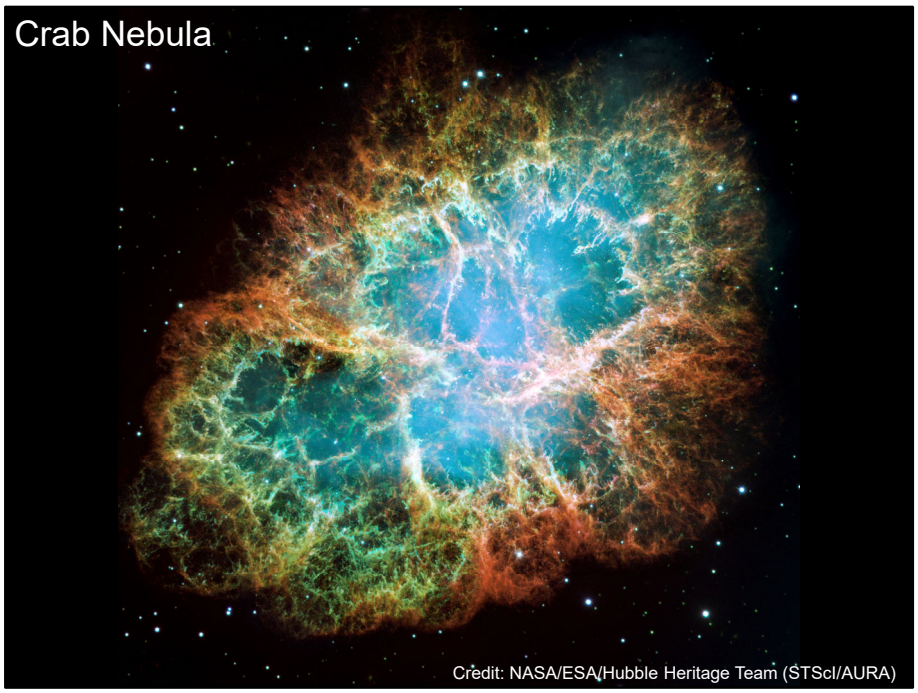


NASA's Hubble Space Telescope has revisited the famous Pillars of Creation, revealing a sharper and wider view of the structures in this visible-light image.

Astronomers combined several Hubble exposures to assemble the wider view. The towering pillars are about 5 light-years tall. The dark, finger-like feature at bottom right may be a smaller version of the giant pillars. The new image was taken with Hubble's versatile and sharp-eyed Wide Field Camera 3.

The pillars are bathed in the blistering ultraviolet light from a grouping of young, massive stars located off the top of the image. Streamers of gas can be seen bleeding off the pillars as the intense radiation heats and evaporates it into space. Denser regions of the pillars are shadowing material beneath them from the powerful radiation. Stars are being born deep inside the pillars, which are made of cold hydrogen gas laced with dust. The pillars are part of a small region of the Eagle Nebula, a vast star-forming region 6,500 light-years from Earth.

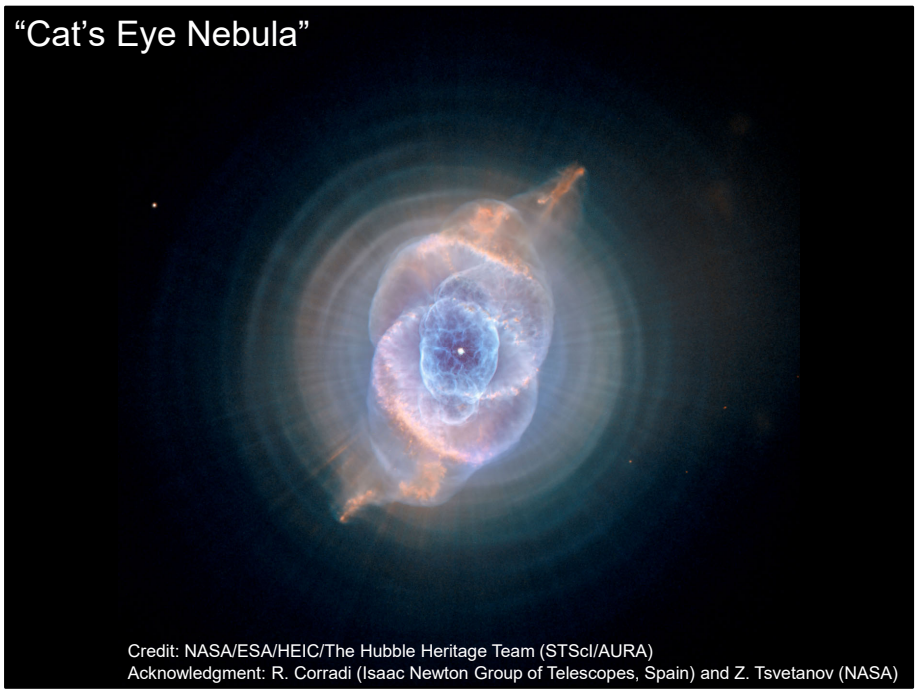
The colors in the image highlight emission from several chemical elements. Oxygen emission is blue, sulfur is orange, and hydrogen and nitrogen are green.



This is a mosaic image, one of the largest ever taken by NASA's Hubble Space Telescope of the Crab Nebula, a six-light-year-wide expanding remnant of a star's supernova explosion. Japanese and Chinese astronomers recorded this violent event nearly 1,000 years ago in 1054, as did, almost certainly, Native Americans.

The orange filaments are the tattered remains of the star and consist mostly of hydrogen. The rapidly spinning neutron star embedded in the center of the nebula is the dynamo powering the nebula's eerie interior bluish glow. The blue light comes from electrons whirling at nearly the speed of light around magnetic field lines from the neutron star. The neutron star, like a lighthouse, ejects twin beams of radiation that appear to pulse 30 times a second due to the neutron star's rotation. A neutron star is the crushed ultra-dense core of the exploded star.

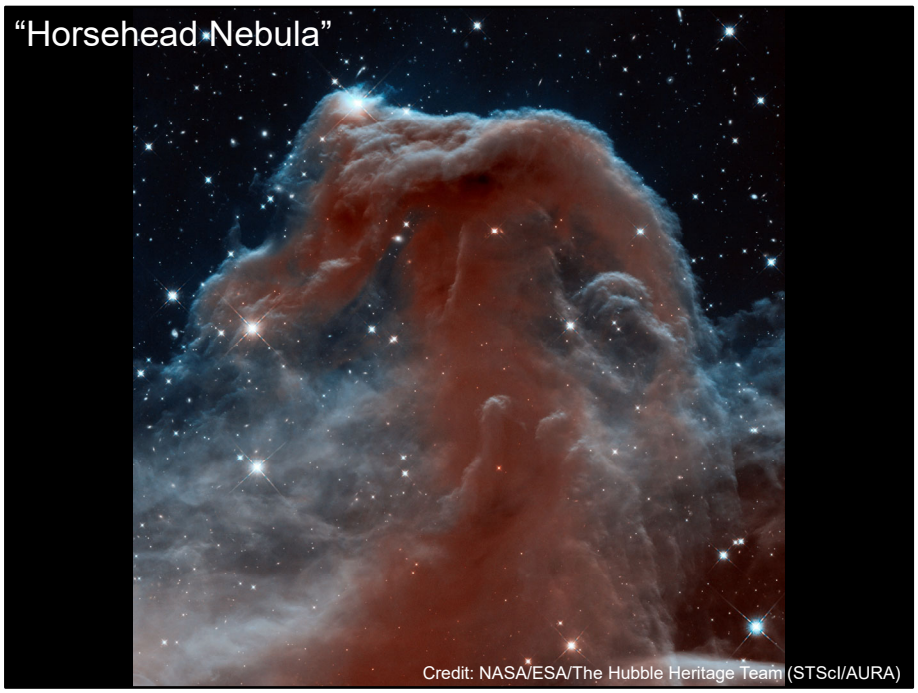
The Crab Nebula derived its name from its appearance in a drawing made by Irish astronomer Lord Rosse in 1844, using a 36-inch telescope. When viewed by Hubble, as well as by large ground-based telescopes such as the European Southern Observatory's Very Large Telescope, the Crab Nebula takes on a more detailed appearance that yields clues into the spectacular demise of a star, 6,500 light-years away.



In 1994, Hubble first revealed NGC 6543’s (Cat’s Eye Nebula) surprisingly intricate structures, including concentric gas shells, jets of high-speed gas, and unusual shock-induced knots of gas.

As if the Cat's Eye itself isn't spectacular enough, this new image taken with Hubble's Advanced Camera for Surveys (ACS) reveals the full beauty of a bull's eye pattern of eleven or even more concentric rings, or shells, around the Cat's Eye. Each 'ring' is actually the edge of a spherical bubble seen projected onto the sky - that's why it appears bright along its outer edge.

Approximately 1,000 years ago the pattern of mass loss suddenly changed, and the Cat's Eye Nebula started forming inside the dusty shells. It has been expanding ever since, as discernible in comparing Hubble images taken in 1994, 1997, 2000, and 2002. The puzzle is what caused this dramatic change? Many aspects of the process that leads a star to lose its gaseous envelope are still poorly known, and the study of planetary nebulae is one of the few ways to recover information about these last few thousand years in the life of a Sun-like star.

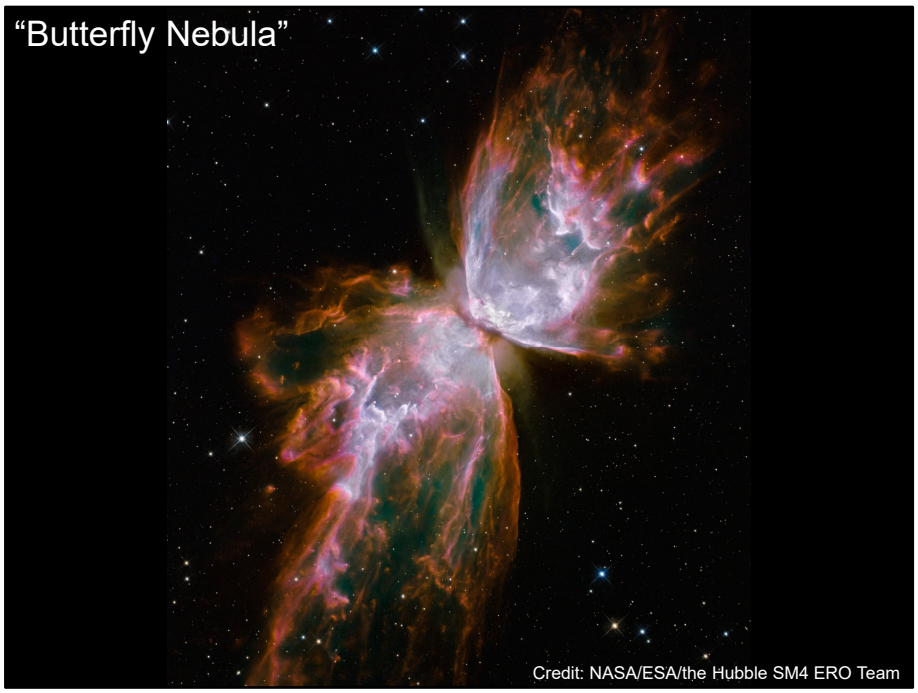


Looking like an apparition rising from whitecaps of interstellar foam, the iconic Horsehead Nebula has graced astronomy books ever since its discovery over a century ago. The nebula is a favorite target for amateur and professional astronomers.

In this new Hubble Space Telescope view, the nebula appears in a new light, as seen in infrared wavelengths. The nebula, shadowy in optical light, appears transparent and ethereal when seen in the infrared, represented here with visible shades. The rich tapestry of the Horsehead Nebula pops out against the backdrop of Milky Way stars and distant galaxies that are easily seen in infrared light.

Gas clouds surrounding the Horsehead have already dissipated, but the tip of the jutting pillar contains a slightly higher density of hydrogen and helium, laced with dust. This casts a shadow that protects material behind it from being photo-evaporated, and a pillar structure forms. Astronomers estimate that the Horsehead formation has about five million years left before it too disintegrates.

The Horsehead Nebula is part of a much larger complex in the constellation Orion. Known collectively as the Orion Molecular Cloud, it also houses other famous objects such as the Great Orion Nebula (M42), the Flame Nebula, and Barnard's Loop.



This celestial object looks like a delicate butterfly. But it is far from serene.

What resemble dainty butterfly wings are actually roiling cauldrons of gas heated to more than 36,000 degrees Fahrenheit. The gas is tearing across space at more than 600,000 miles an hour – fast enough to travel from Earth to the Moon in 24 minutes!

A dying star that was once about five times the mass of the Sun is at the center of this fury. It has ejected its envelope of gases and is now unleashing a stream of ultraviolet radiation that is making the cast-off material glow. This object is an example of a planetary nebula, so-named because many of them have a round appearance resembling that of a planet when viewed through a small telescope.

The Wide Field Camera 3 (WFC3), a new camera aboard NASA's Hubble Space Telescope, snapped this image of the planetary nebula, catalogued as NGC 6302, but more popularly called the Bug Nebula or the Butterfly Nebula.

NGC 6302 lies within our Milky Way galaxy, roughly 3,800 light-years away in the constellation Scorpius. The glowing gas is the star's outer layers, expelled over about 2,200 years. The "butterfly" stretches for more than two light-years, which is about half the distance from the Sun to the nearest star, Alpha Centauri.

Galaxy

- A galaxy is a massive, gravitationally bound system that consists of stars and stellar remnants, an interstellar medium of gas and dust, and an important but poorly understood component tentatively dubbed dark matter

https://youtu.be/tj_QPnO8vpQ

A few short stacked exposures of a section of the Carina–Sagittarius Arm (also called the Sagittarius Arm) of the Milky Way Galaxy (imaged along the galactic plane, because we're in the disk of the spiral).

The centre of our galaxy, the Milky Way Galaxy, from New Zealand (Southern Hemisphere).

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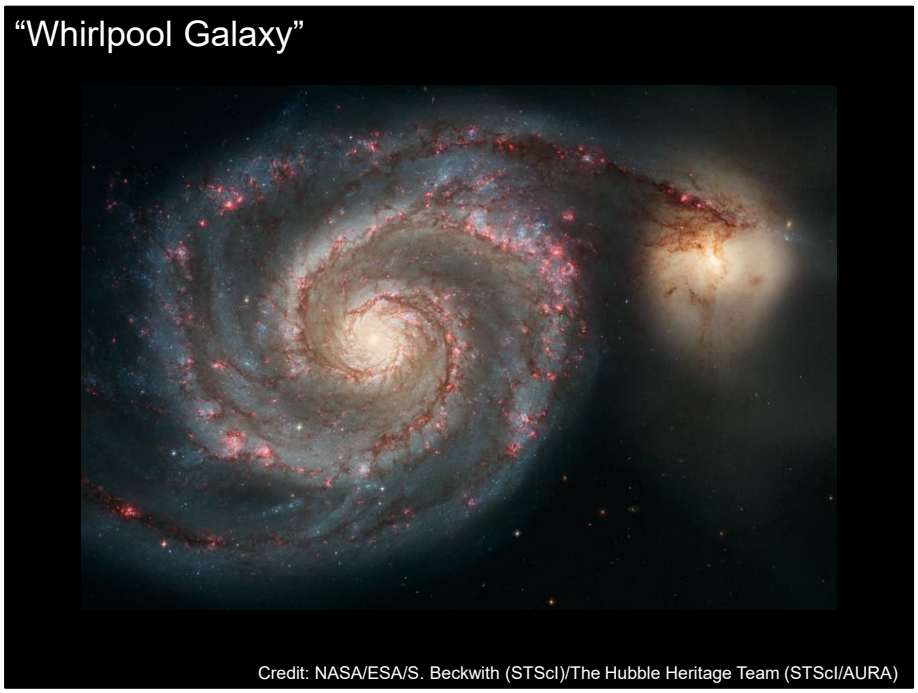
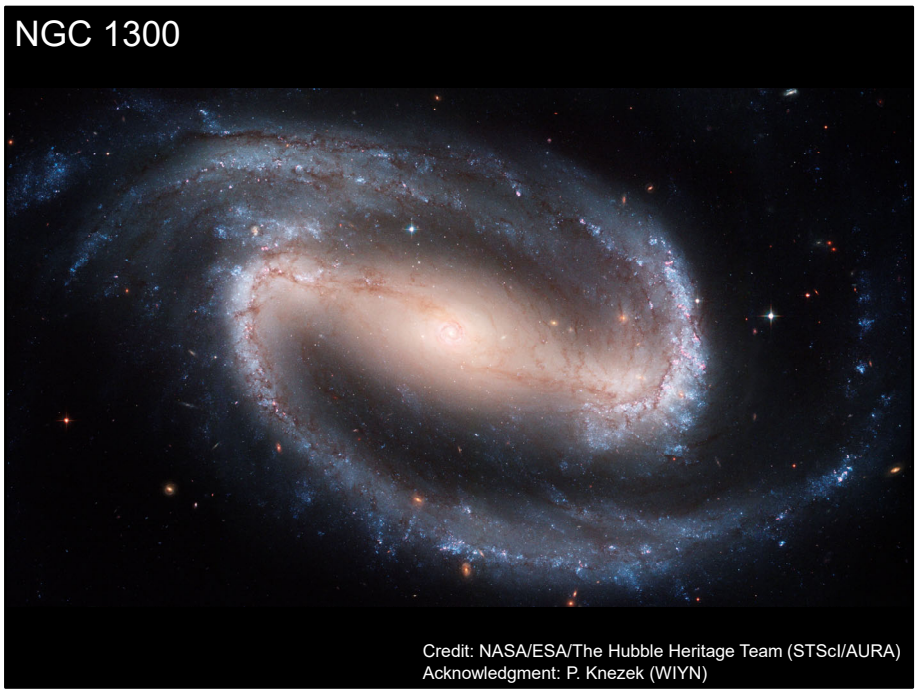


The graceful, winding arms of the majestic spiral galaxy M51 (NGC 5194) appear like a grand spiral staircase sweeping through space. They are actually long lanes of stars and gas laced with dust.

This sharpest-ever image of the Whirlpool Galaxy, taken in January 2005 with the Advanced Camera for Surveys aboard NASA's Hubble Space Telescope, illustrates a spiral galaxy's grand design, from its curving spiral arms, where young stars reside, to its yellowish central core, a home of older stars. The galaxy is nicknamed the Whirlpool because of its swirling structure.

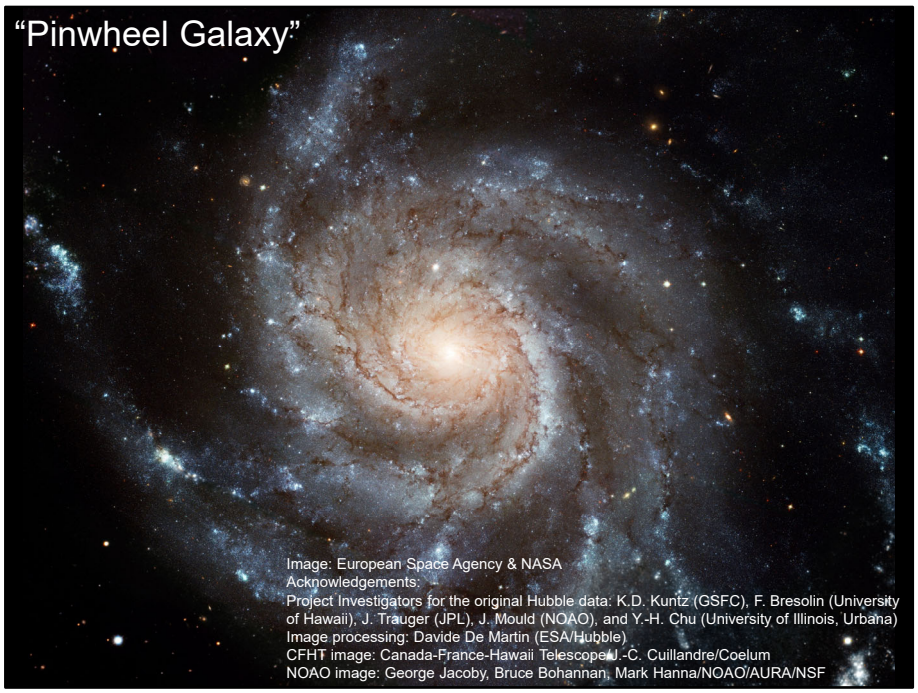
The Whirlpool's most striking feature is its two curving arms, a hallmark of so-called grand-design spiral galaxies. Many spiral galaxies possess numerous, loosely shaped arms which make their spiral structure less pronounced. These arms serve an important purpose in spiral galaxies. They are star-formation factories, compressing hydrogen gas and creating clusters of new stars. In the Whirlpool, the assembly line begins with the dark clouds of gas on the inner edge, then moves to bright pink star-forming regions, and ends with the brilliant blue star clusters along the outer edge.



The Hubble telescope captured a display of starlight, glowing gas, and silhouetted dark clouds of interstellar dust in this 4-foot-by-8-foot image of the barred spiral galaxy NGC 1300. NGC 1300 is considered to be prototypical of barred spiral galaxies. Barred spirals differ from normal spiral galaxies in that the arms of the galaxy do not spiral all the way into the center, but are connected to the two ends of a straight bar of stars containing the nucleus at its center.

At Hubble's resolution, a myriad of fine details, some of which have never before been seen, is seen throughout the galaxy's arms, disk, bulge, and nucleus. Blue and red supergiant stars, star clusters, and star-forming regions are well resolved across the spiral arms, and dust lanes trace out fine structures in the disk and bar. Numerous more distant galaxies are visible in the background, and are seen even through the densest regions of NGC 1300.

NGC 4414, a typical spiral galaxy in the constellation Coma Berenices, is about 55,000 light-years in diameter and approximately 60 million light-years away from Earth.



The galaxy Messier 101 (M101, also known as NGC 5457 and also nicknamed the Pinwheel Galaxy) lies in the northern circumpolar constellation, Ursa Major (The Great Bear), at a distance of about 21 million light-years from Earth. This is one of the largest and most detailed photos of a spiral galaxy that has been released from Hubble. The galaxy's portrait is actually composed of 51 individual Hubble exposures, in addition to elements from images from ground-based photos.

Black Hole

- A black hole is a place in space where gravity pulls so much that even light can not get out.
- The gravity is so strong because matter has been squeezed into a tiny space.
- This can happen when a star is dying.

- A black hole can not be seen because strong gravity pulls all the light into the middle of the black hole.
- Although light can't escape a black hole's event horizon, the enormous tidal forces in its vicinity cause nearby matter to heat up to millions of degrees and emit radio waves and X-rays.
  - satellites and telescopes in space are used to detect the radio waves and X-rays

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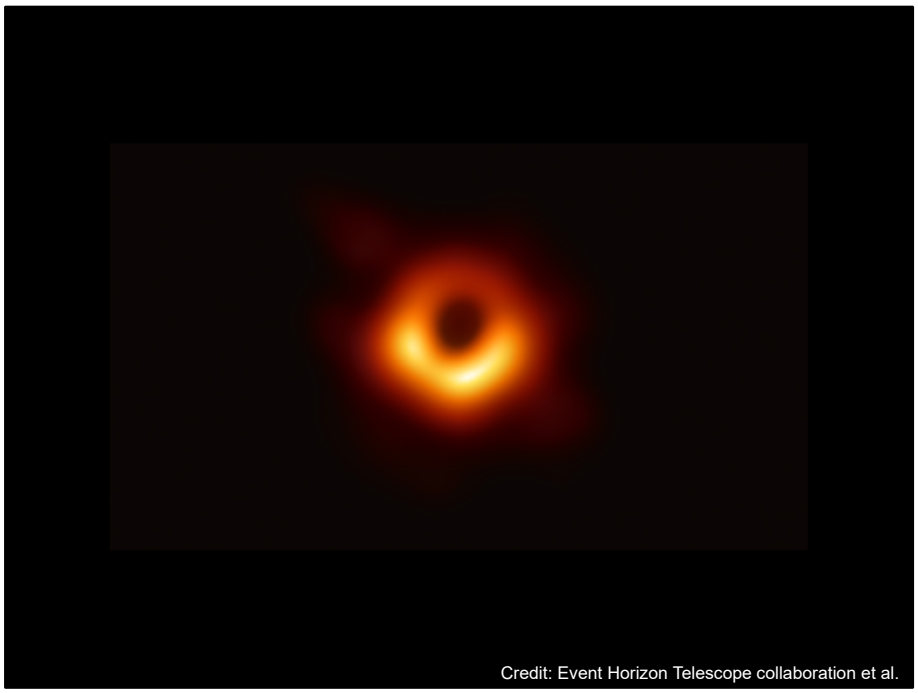

On April 2019, a black hole and its shadow were captured in an image for the first time, a historic feat by an international network of radio telescopes called the Event Horizon Telescope (EHT). EHT is an international collaboration whose support in the U.S. includes the National Science Foundation.

This stunning image shows the shadow of the supermassive black hole in the center of Messier 87 (M87), an elliptical galaxy some 55 million light-years from Earth. This black hole is 6.5 billion times the mass of the Sun. Catching its shadow involved eight ground-based radio telescopes around the globe, operating together as if they were one telescope the size of our entire planet.

The first picture of a black hole was made using observations of the center of galaxy M87 taken by the Event Horizon Telescope. The image shows a bright ring formed as light bends in the intense gravity around a black hole 6.5 billion times the Sun’s mass.

https://skyandtelescope.org/interactive-sky-chart/