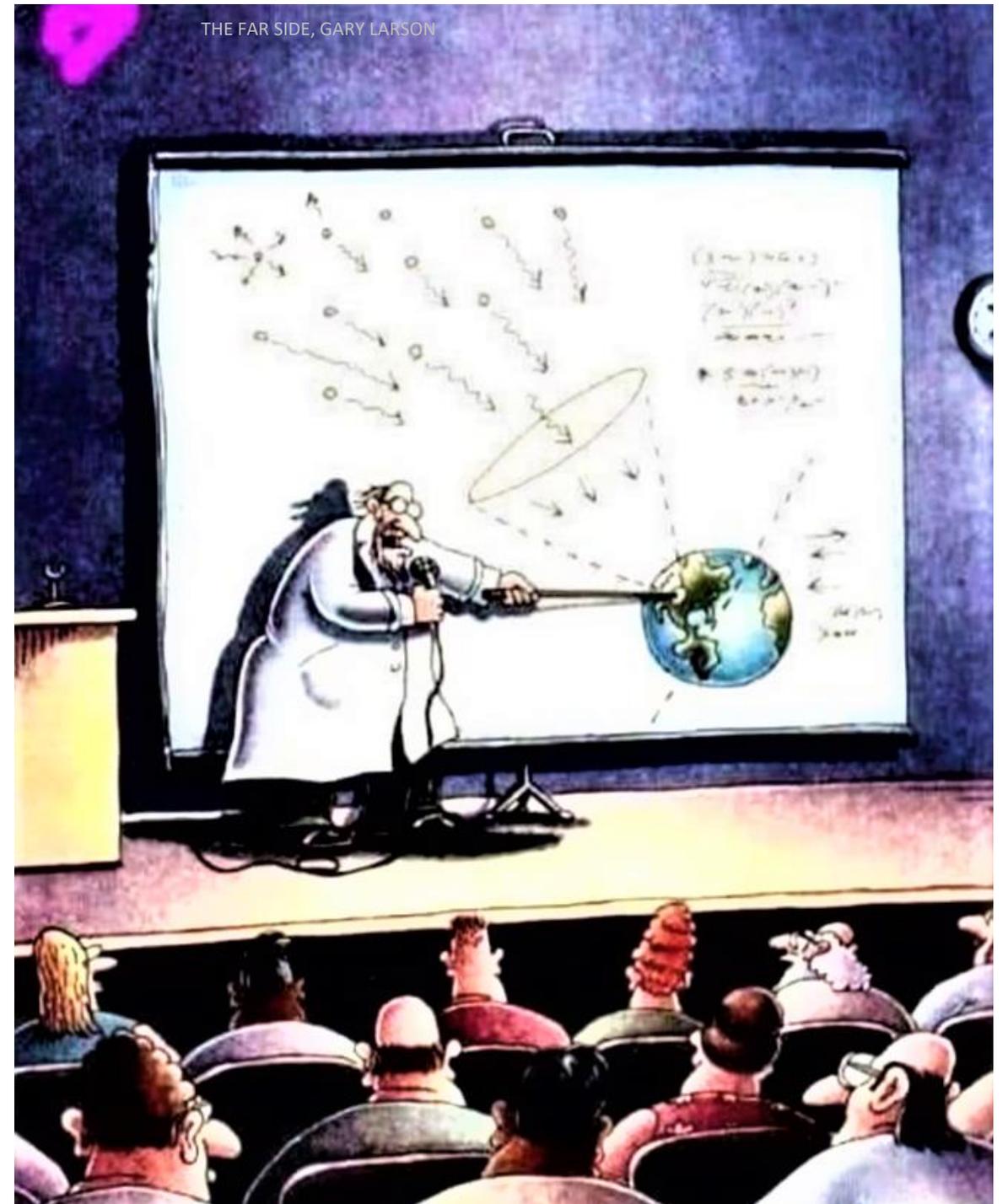
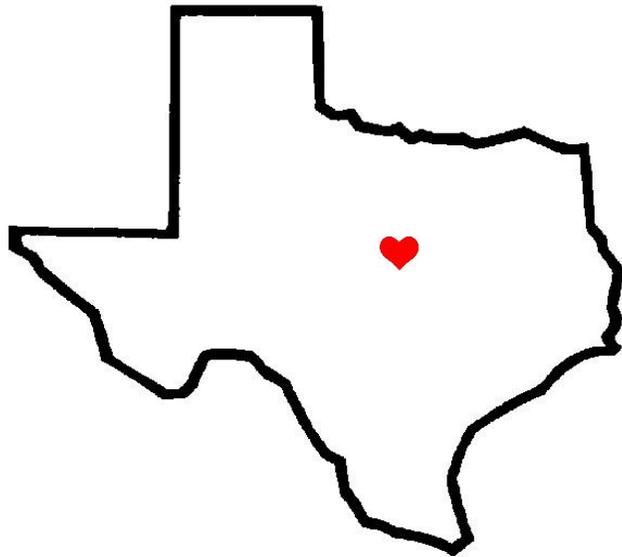


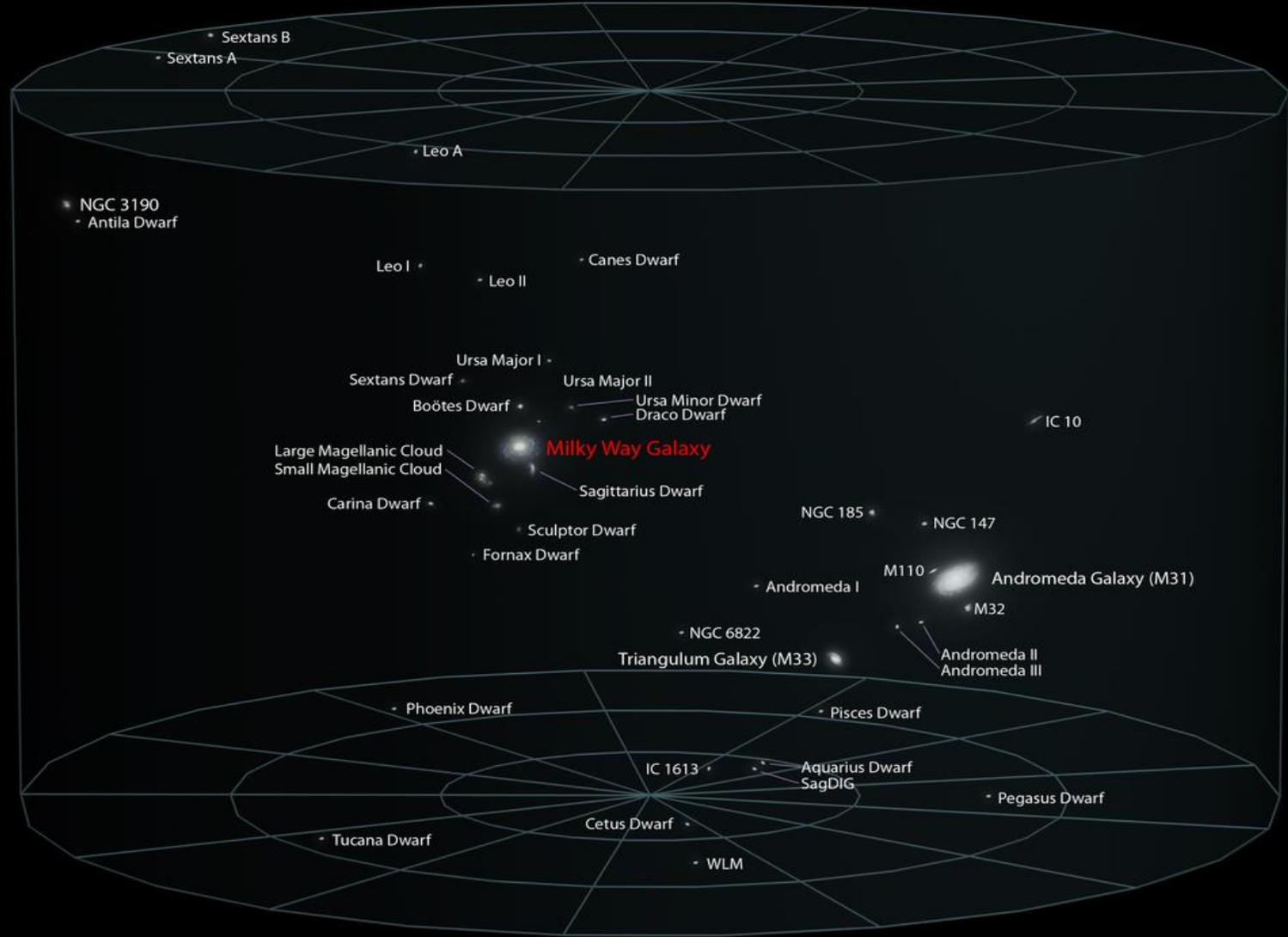
PLANETARY BODIES

“So, in the general relativistic sense, we find that the dynamic friction of the tensor light cone is actually negative, creating a local convergence of photons, which causes the stars at night to be big and bright... especially here, deep in the heart of Texas.”

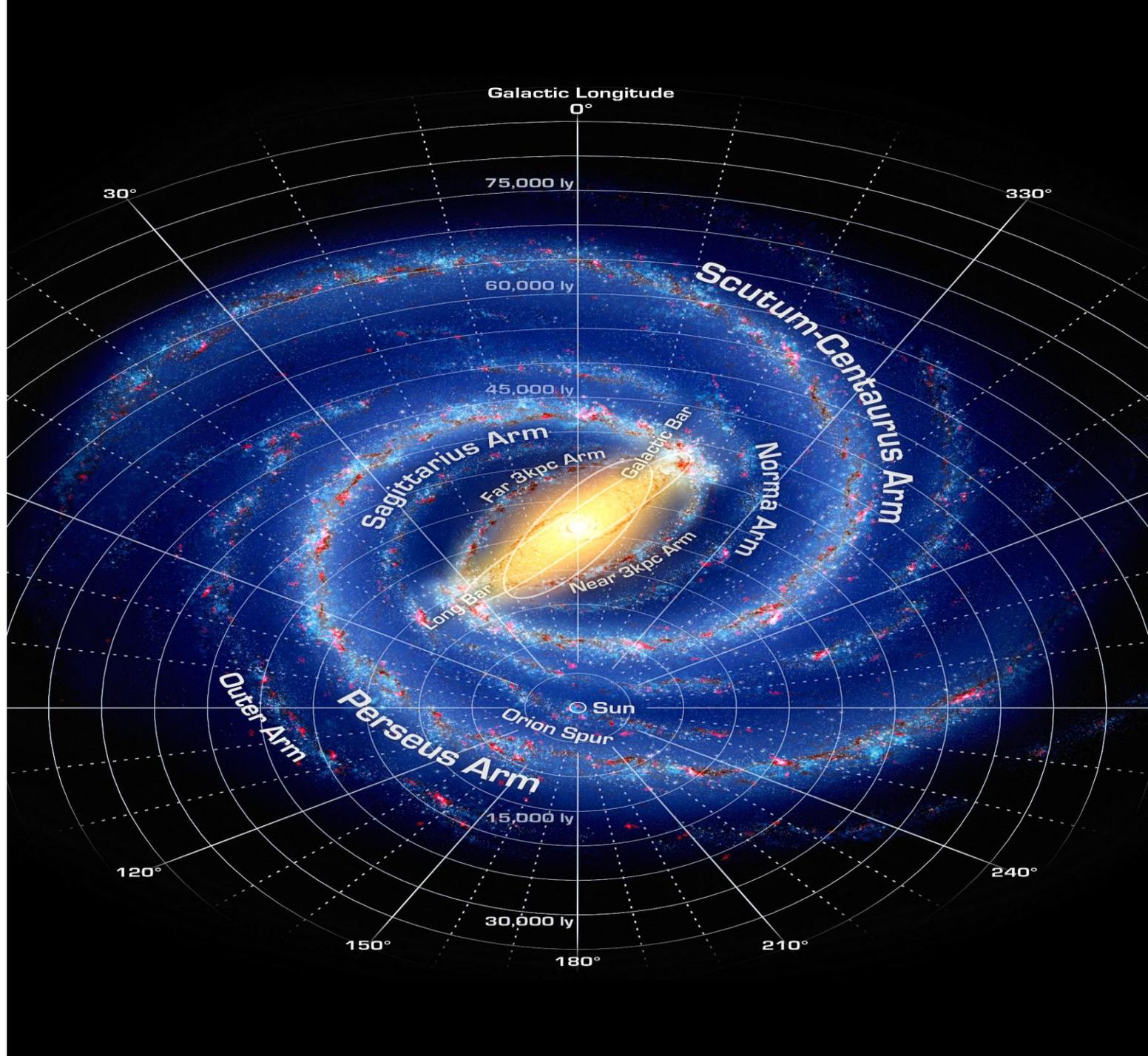


Local Galactic Group

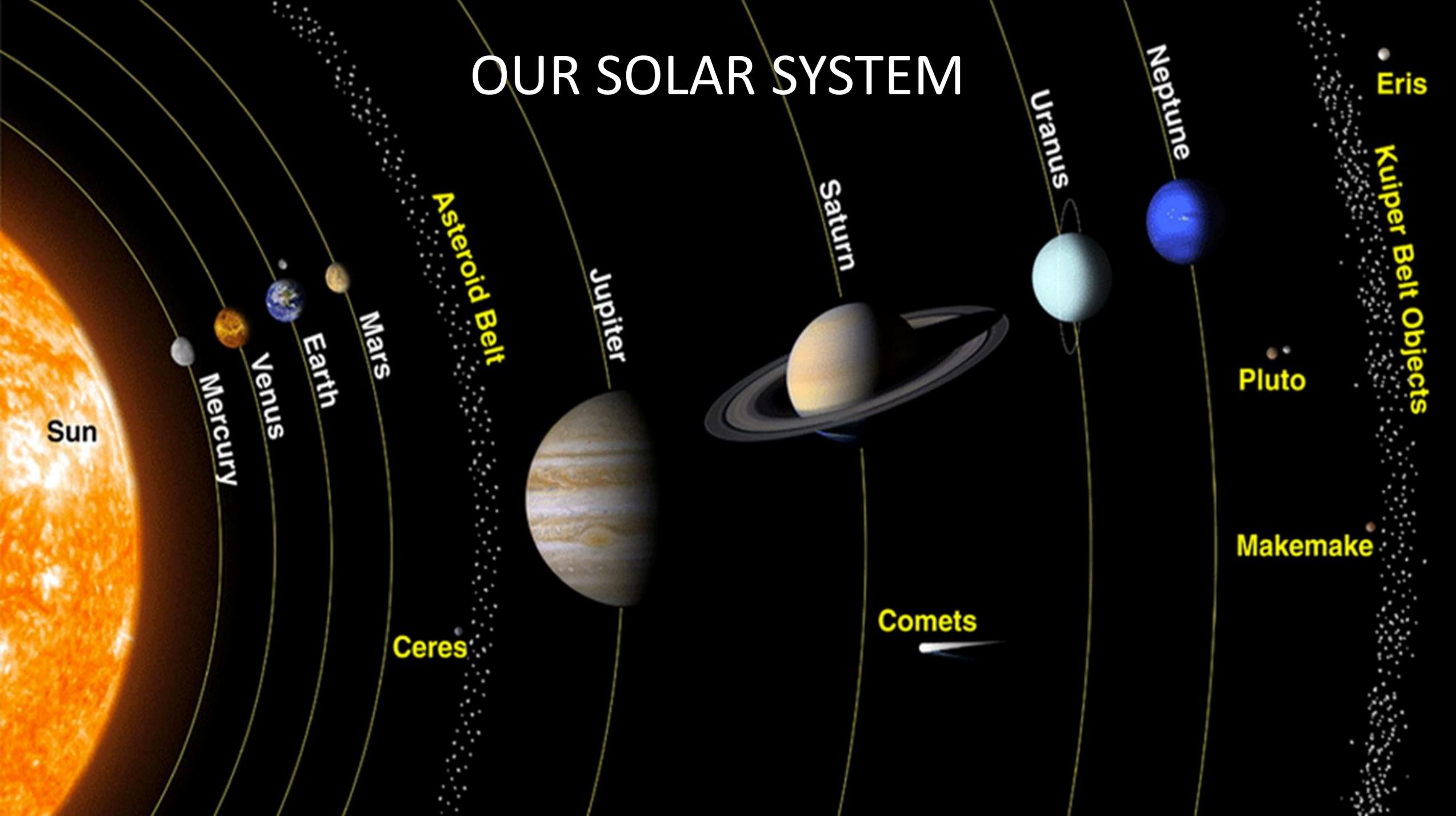
- The Milky Way galaxy is one of more than 54 galaxies known as the Local Group. They are spread over a diameter of nearly 10 million light years.
- The three largest members of the group are our Milky Way (second-biggest), the Andromeda galaxy (biggest) and the Triangulum Galaxy.
- The other galaxies in the Local Group are dwarf galaxies, and they're mostly clustered around the three larger galaxies.



- Milky Way Galaxy is a large spiral system consisting of several hundred billion stars, one of which is the [Sun](#).
- It takes its name from the irregular luminous band of stars and gas clouds that stretches across the sky as seen from Earth.
- The Milky Way gets its name from a Greek myth about the goddess Hera who sprayed milk across the sky.
- The width of the Milky Way Galaxy measures from 100,000 to 120,000 light years in width.
- Our solar system lies some 25,000 light years from the galactic center.
- It takes some 200,000,000 years for the solar system to orbit the galactic center.
- Gravity holds it all together.

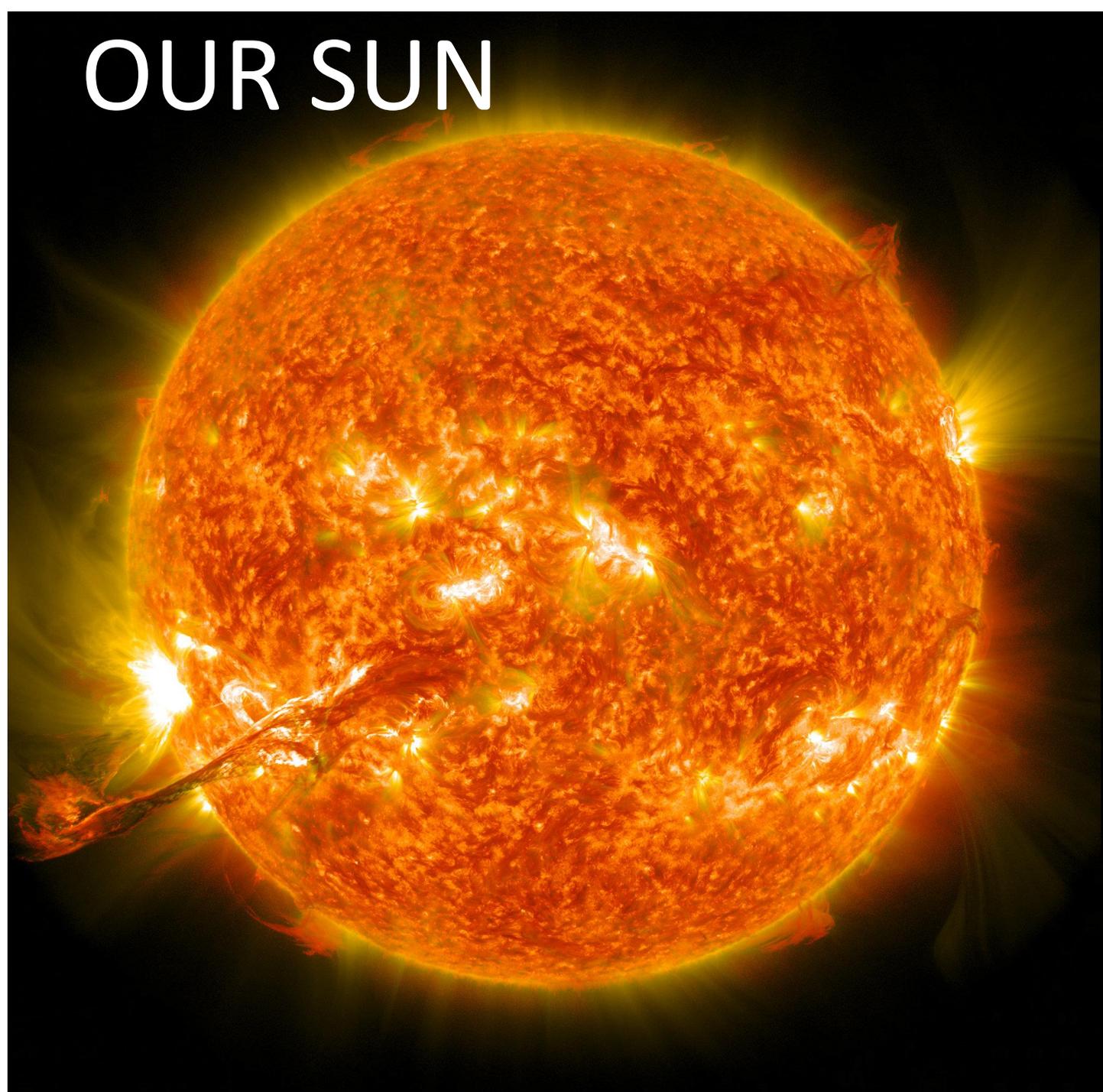


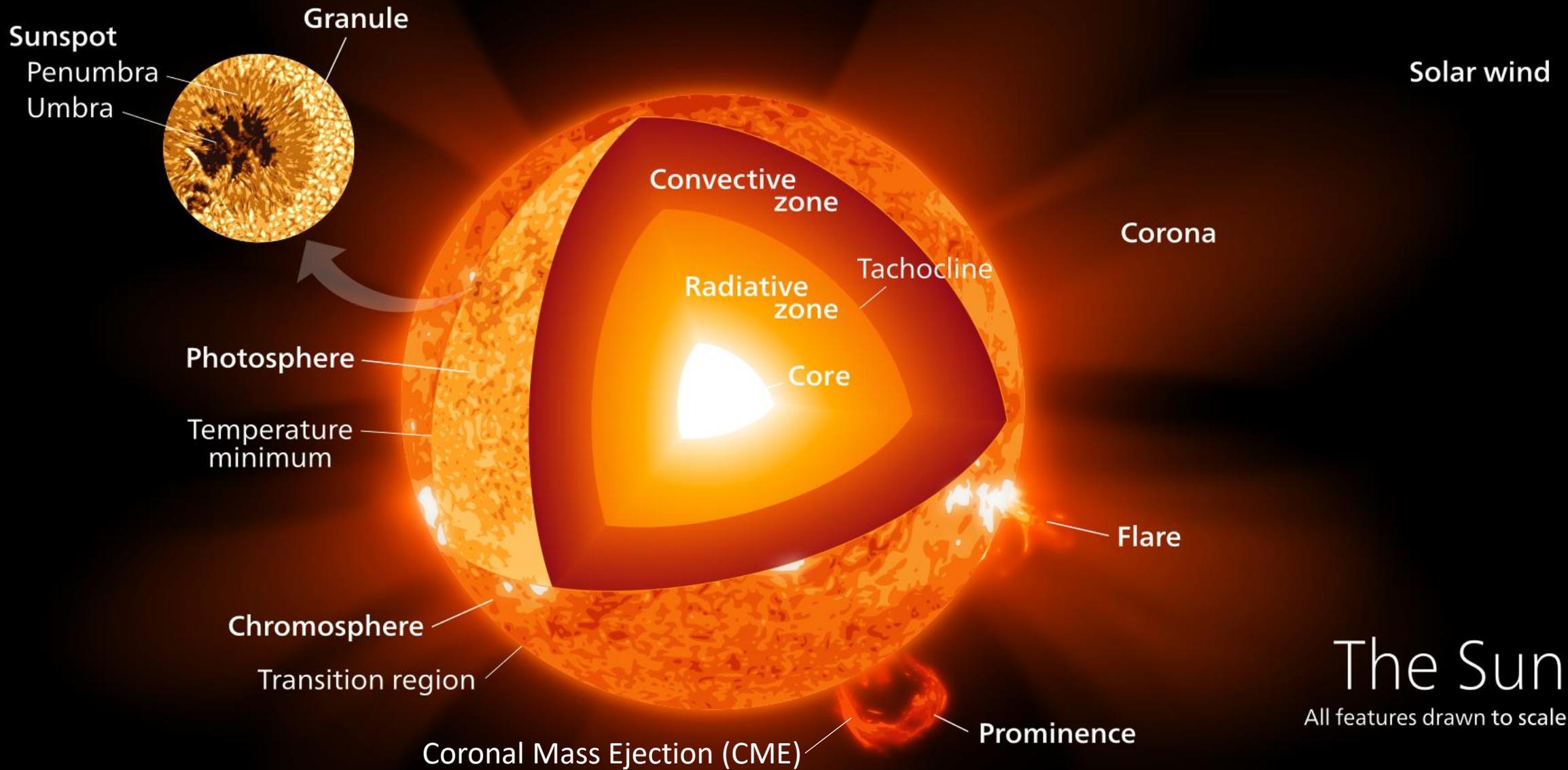
OUR SOLAR SYSTEM

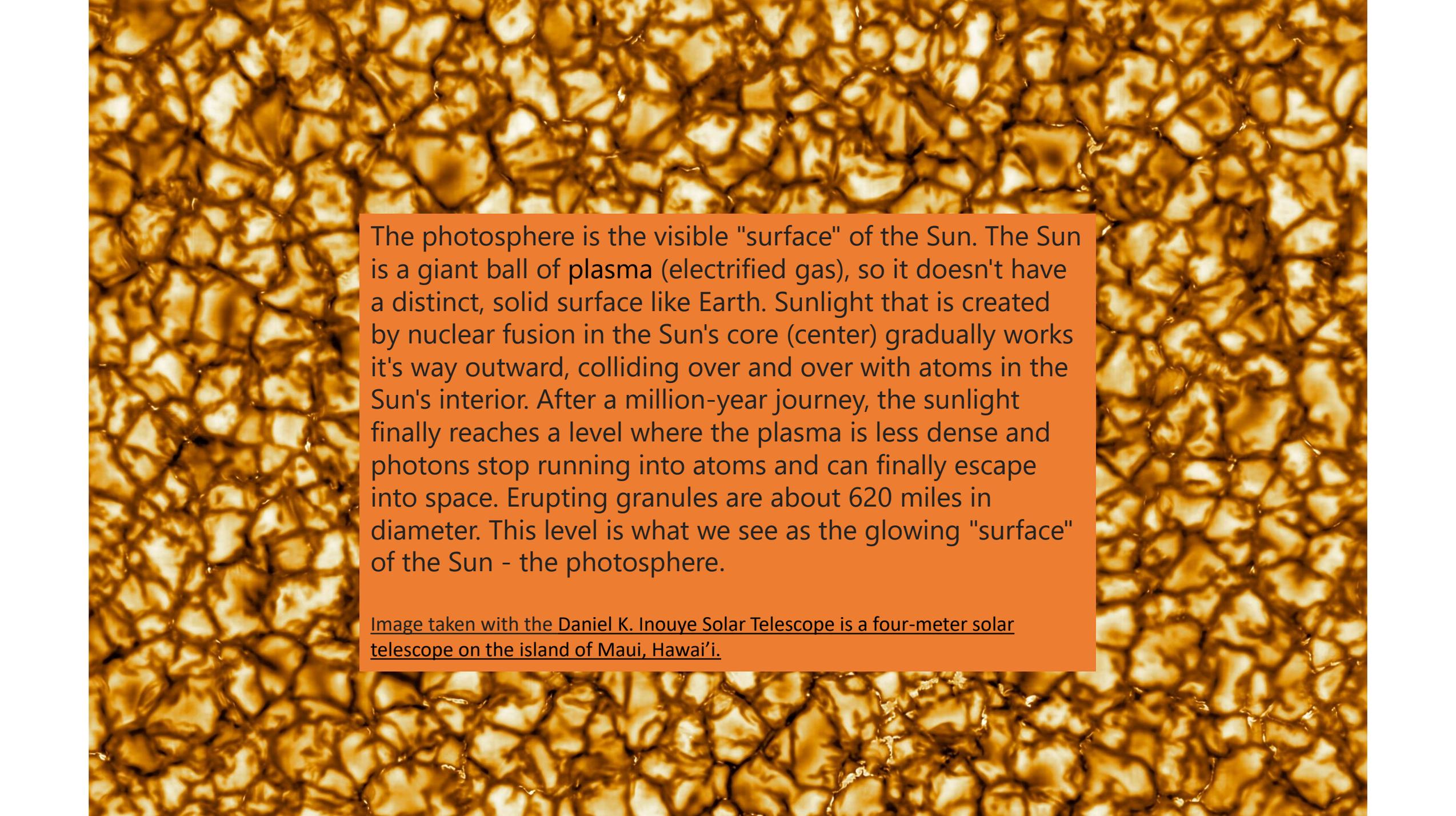


OUR SUN

- The Sun accounts for 99.86% of the mass in the solar system.
- The Sun is over 850,000 miles in diameter
- Over one million Earth's could fit inside the Sun.
- The energy created by the Sun's core is from nuclear fusion. The fusion of two Hydrogen atoms to form one of Helium, which releases huge amounts of energy.
- It takes eight minutes for light reach Earth from the Sun
- Temperatures inside the Sun can reach 27 million degrees Fahrenheit.
- The Sun is classified as a yellow dwarf star

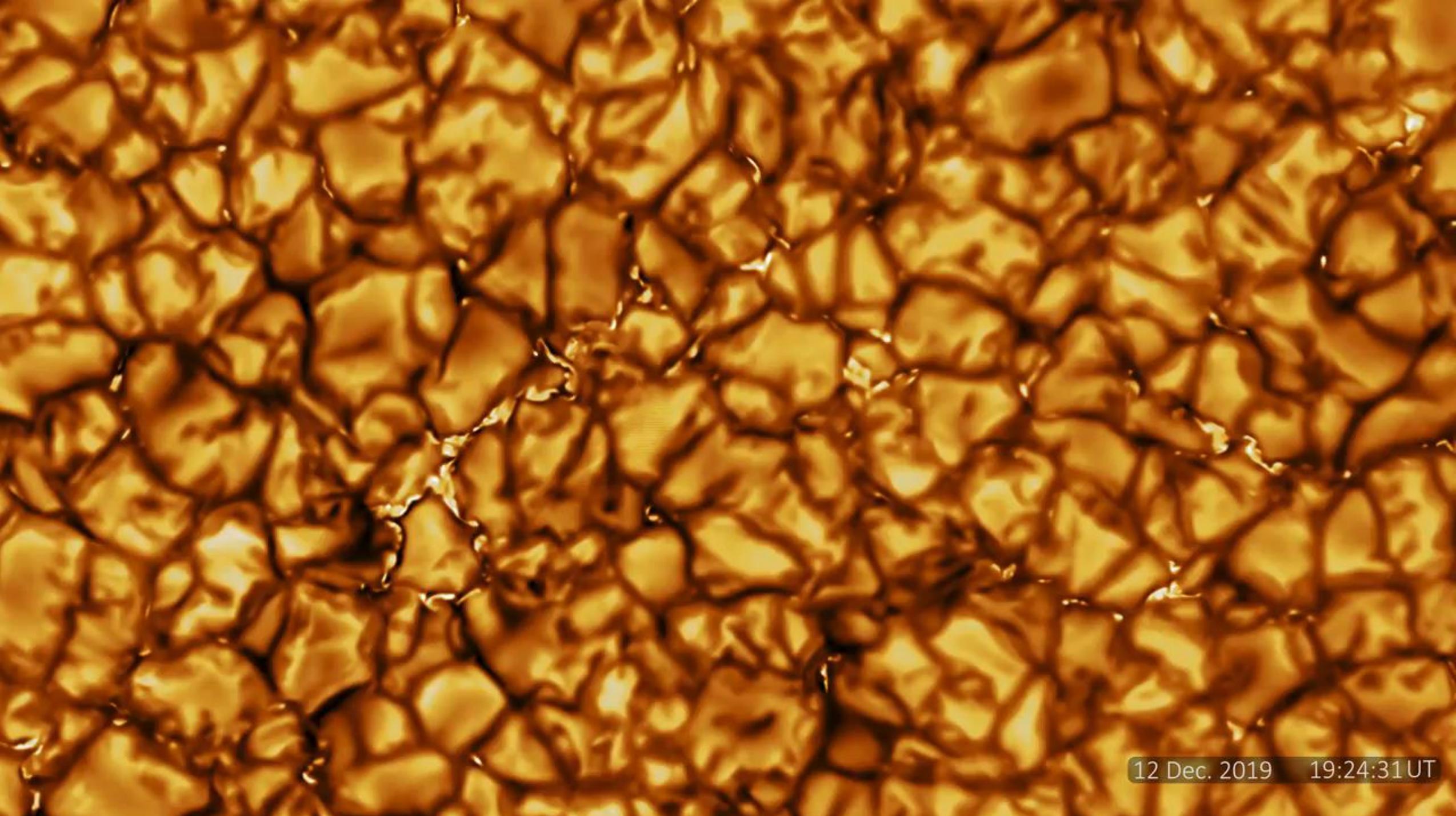






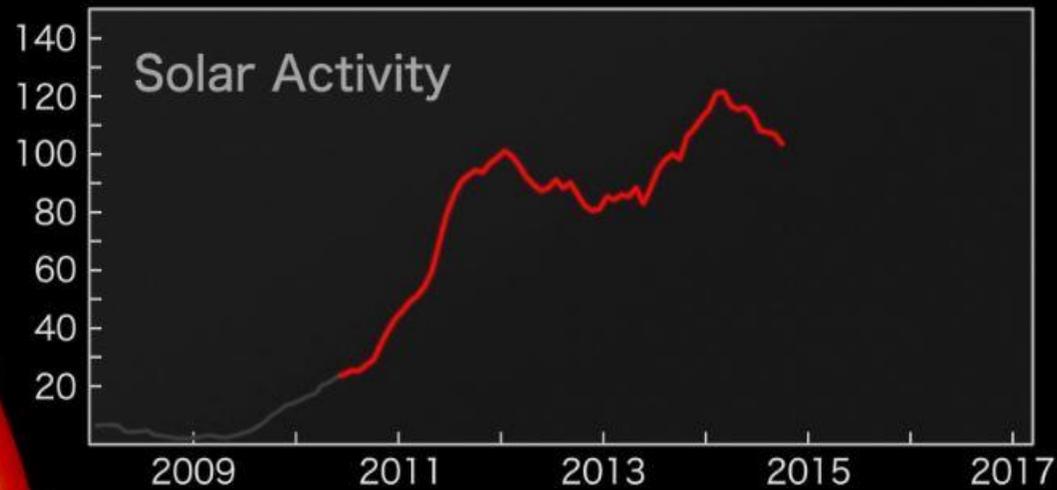
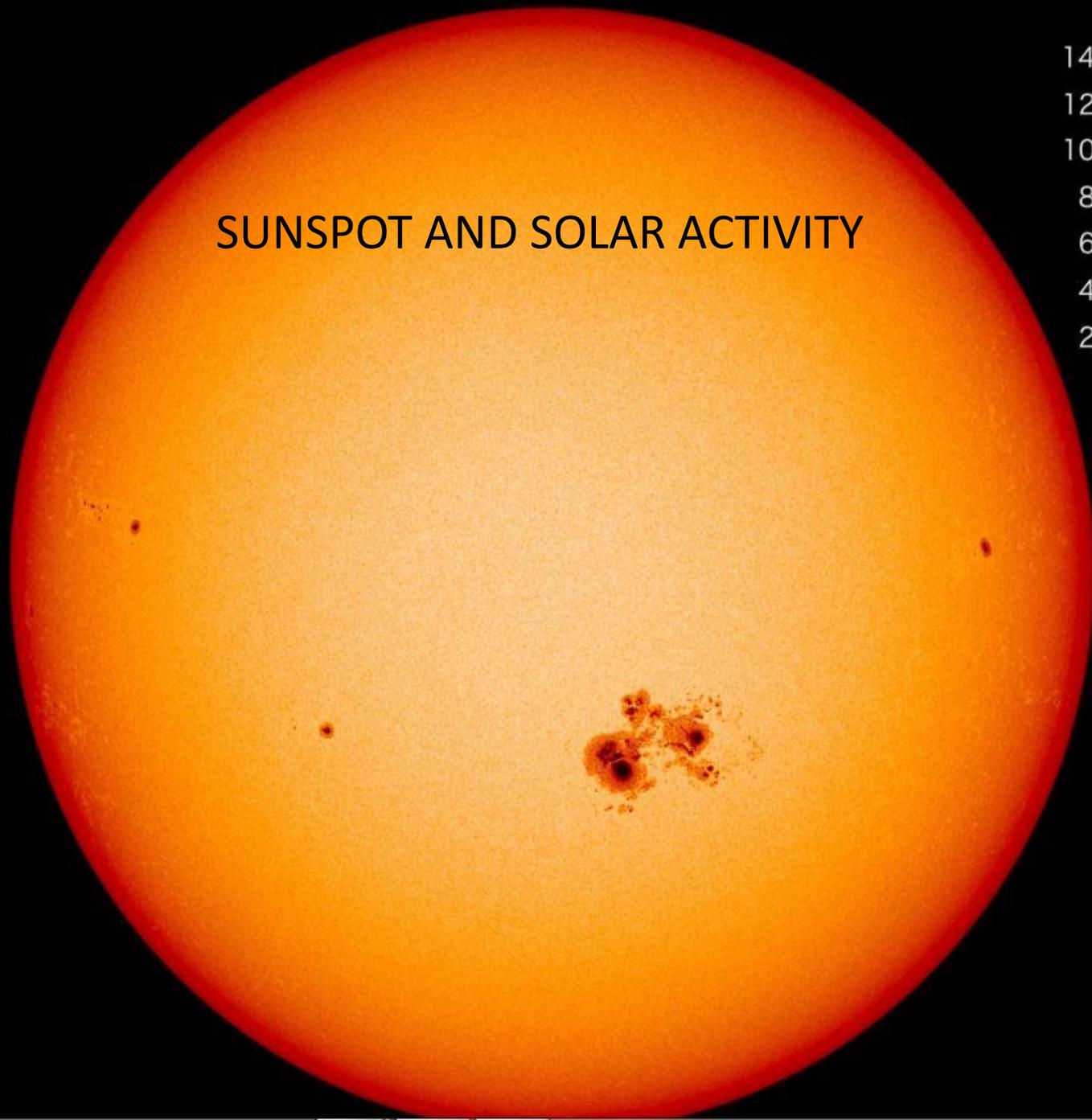
The photosphere is the visible "surface" of the Sun. The Sun is a giant ball of plasma (electrified gas), so it doesn't have a distinct, solid surface like Earth. Sunlight that is created by nuclear fusion in the Sun's core (center) gradually works its way outward, colliding over and over with atoms in the Sun's interior. After a million-year journey, the sunlight finally reaches a level where the plasma is less dense and photons stop running into atoms and can finally escape into space. Erupting granules are about 620 miles in diameter. This level is what we see as the glowing "surface" of the Sun - the photosphere.

Image taken with the Daniel K. Inouye Solar Telescope is a four-meter solar telescope on the island of Maui, Hawai'i.

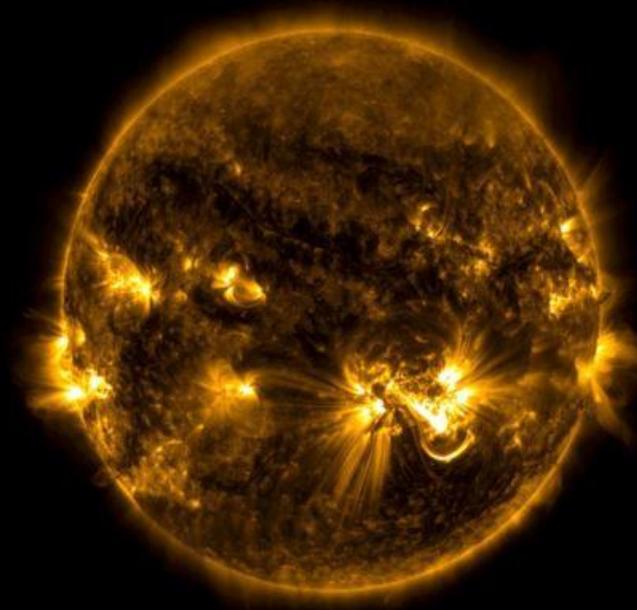


12 Dec. 2019 19:24:31 UT

SUNSPOT AND SOLAR ACTIVITY

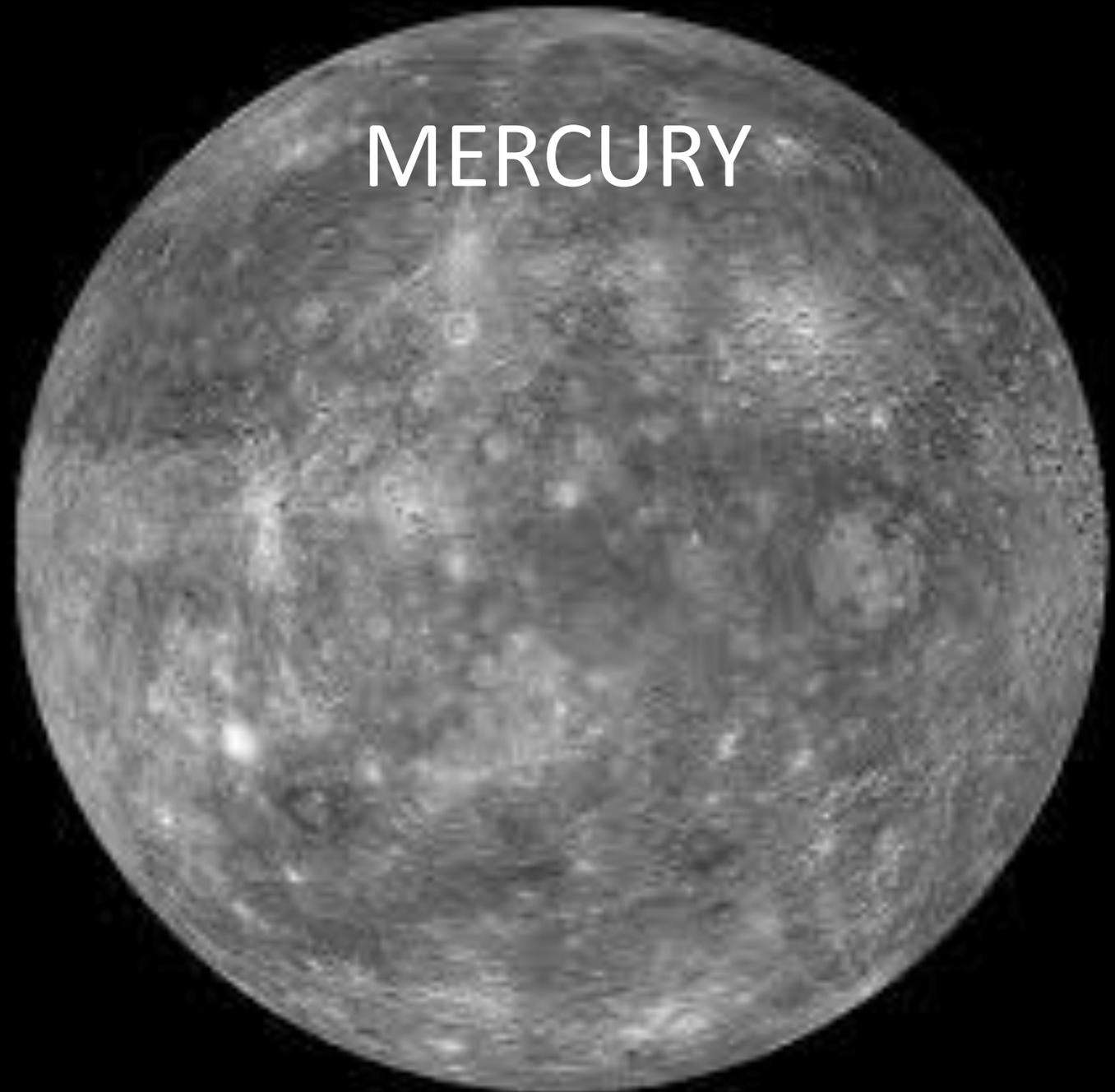


2014 Oct 24

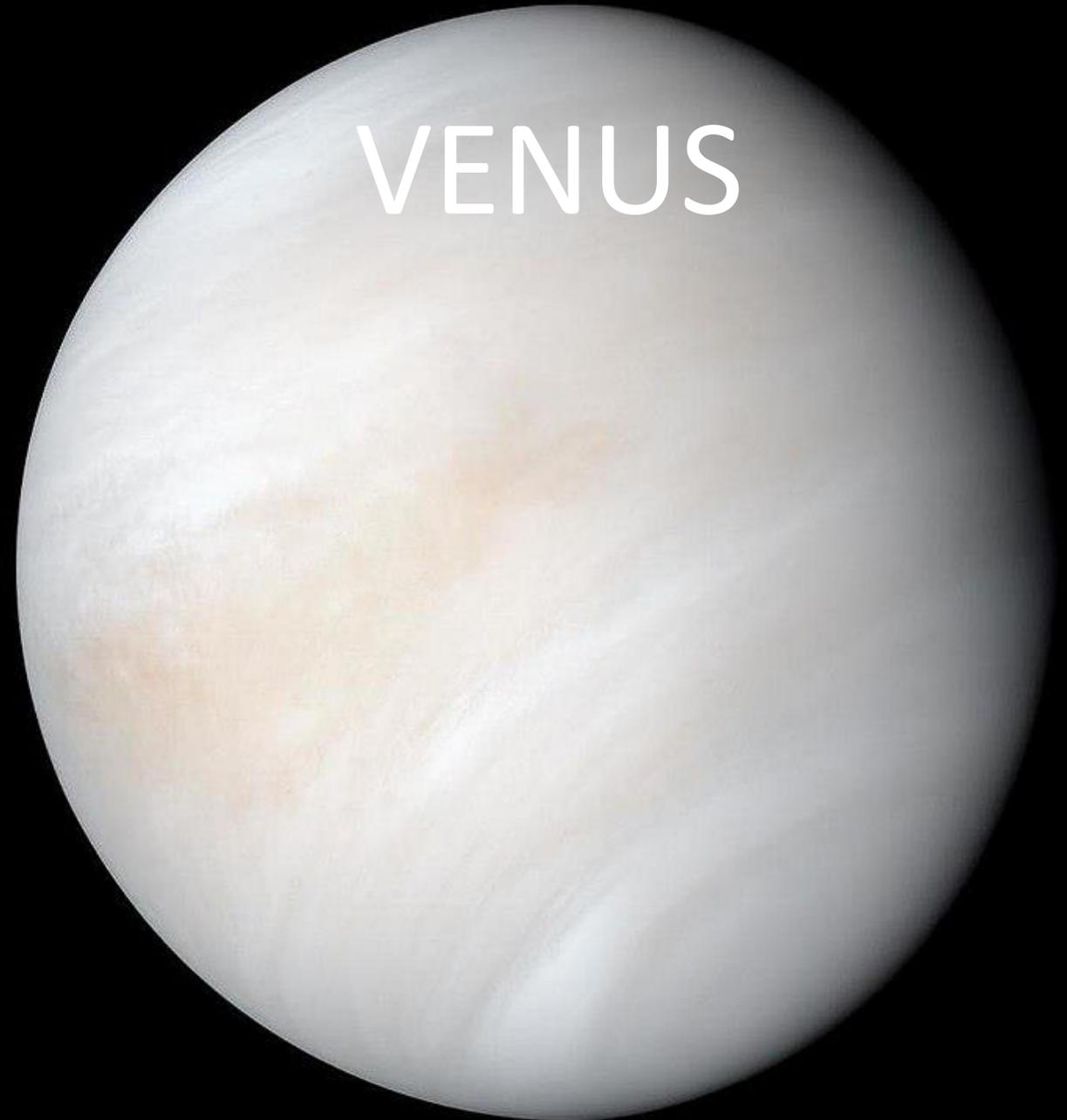


Solar Atmosphere

- Mercury is the smallest planet in our solar system—only slightly larger than Earth's Moon.
- It is the closest planet to the Sun at a distance of about 36 million miles.
- Daytime temperatures can reach 800 degrees Fahrenheit and drop to -290 degrees Fahrenheit at night.
- Standing on Mercury's surface at its closest approach to the Sun, our star would appear more than three times larger than it does on Earth.
- Mercury has phases like Venus and the Moon because it is between the Earth and Sun.



- Venus is the second closest planet to the sun at a distance of about 67 million miles.
- One day on Venus lasts 243 Earth days because Venus spins backwards, with its sun rising in the west and setting in the east.
- Venus' solid surface is a volcanic landscape covered with extensive plains featuring high volcanic mountains and vast ridged plateaus.
- The planet's surface temperature is about 900 degrees Fahrenheit—hot enough to melt lead.
- While the surface rotates slowly, the winds blow at hurricane force, sending clouds completely around the planet every five days.



Phases of Venus

Since Venus is between the Earth and the Sun we see the phases of Venus.



- Observations made by NASA's Magellan spacecraft between 1990 and 1994 form the base of the image, with gaps in the data filled in by the Arecibo Observatory, which is based in Puerto Rico.
- The atmosphere of Venus is composed of 96.5% carbon dioxide, 3.5% nitrogen, and traces of other gases, most notably sulfur dioxide.
- Venus experiences a runaway greenhouse effect because of the high concentration of CO².
- Although Venus and Earth are similar in size, someone standing on the ground on Venus would experience air about 90 times heavier than Earth's atmosphere; pressures are similar to diving 3,000 feet beneath the ocean.



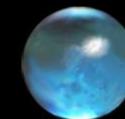
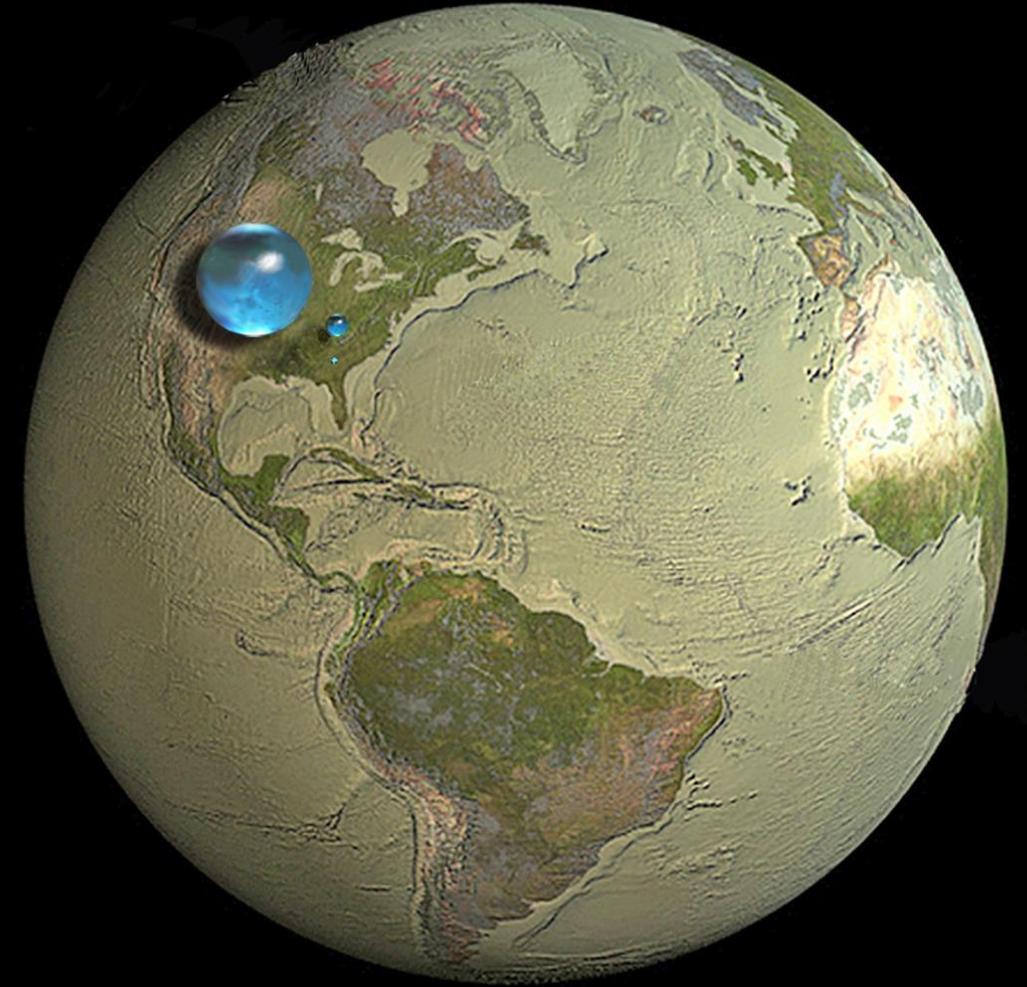
- Earth is the third planet from the Sun at a distance of about 93 million miles
- Earth is a rocky planet with a solid and dynamic surface of mountains, canyons, plains and more. Most of our planet is covered in water.
- Earth's atmosphere is 78 percent nitrogen, 21 percent oxygen and 1 percent other ingredients—the perfect balance to breathe and live.
- Our atmosphere protects us from incoming meteoroids, most of which break up in our atmosphere before they can strike the surface.
- The Earth has a magnetic field that protects us from the Sun's solar wind.
- The Aurora Borealis and Aurora Australis are caused by the interaction of solar winds with Earth's magnetic field.



The World's Water

OUR WATER WORLD

- The average depth of the world's oceans is 12,000 feet
- In total there is 332,000,000 cubic miles of water on, in or above the earth.
- The Earth has a volume of about 260,000,000,000 cubic miles.
- The oceans contain 97% of the world's water, which covers 72% of the Earth's surface.
- The remaining 3% is found in glaciers and ice, below the ground, and in rivers and lakes.



All water on, in, and above the Earth



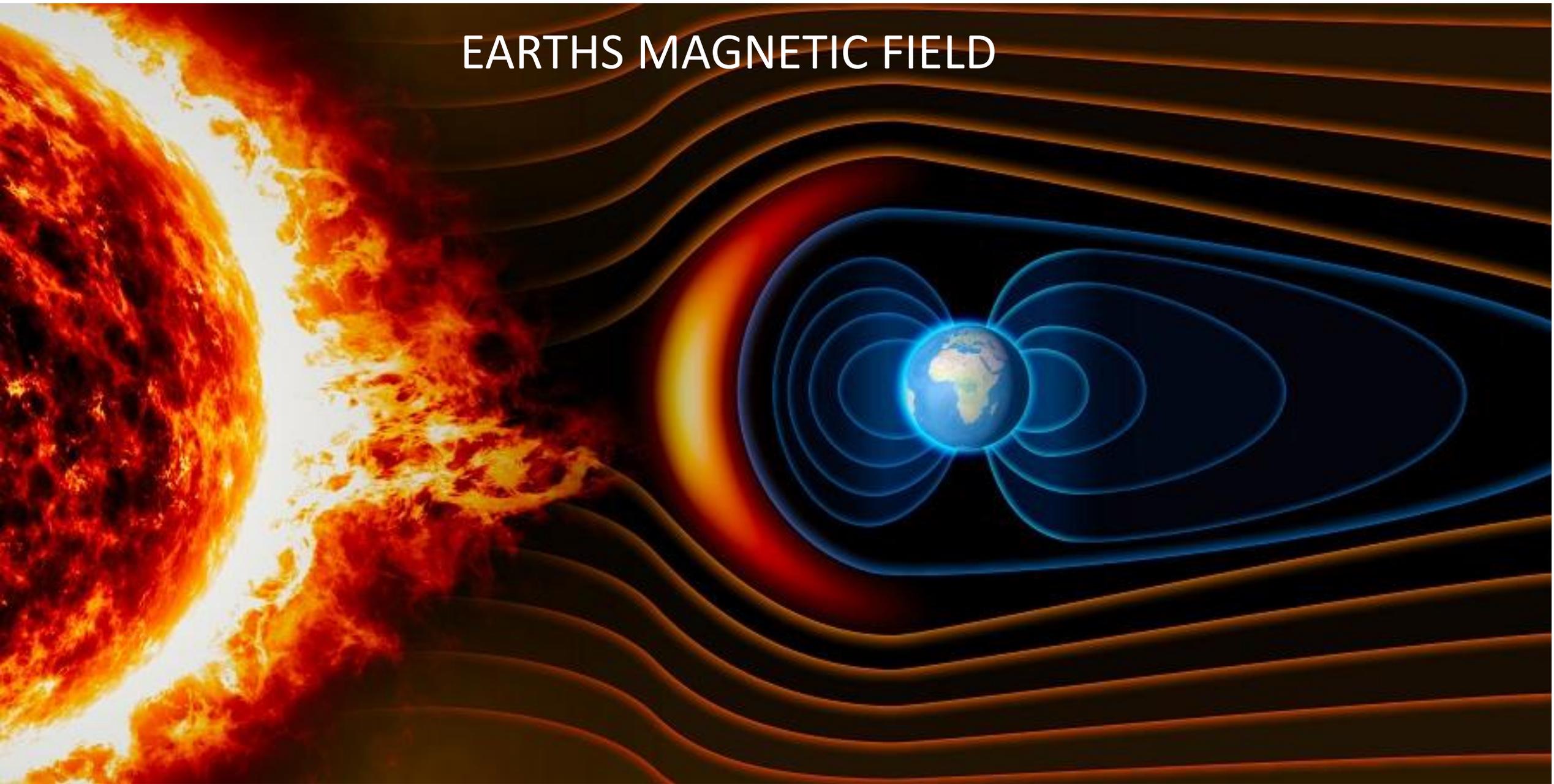
Liquid fresh water



Fresh-water lakes and rivers

Howard Perlman, USGS,
Jack Cook, Woods Hole Oceanographic Institution,
Adam Nieman
Data source: Igor Shiklomanov
<http://ga.water.usgs.gov/edu/earthhowmuch.html>

EARTH'S MAGNETIC FIELD

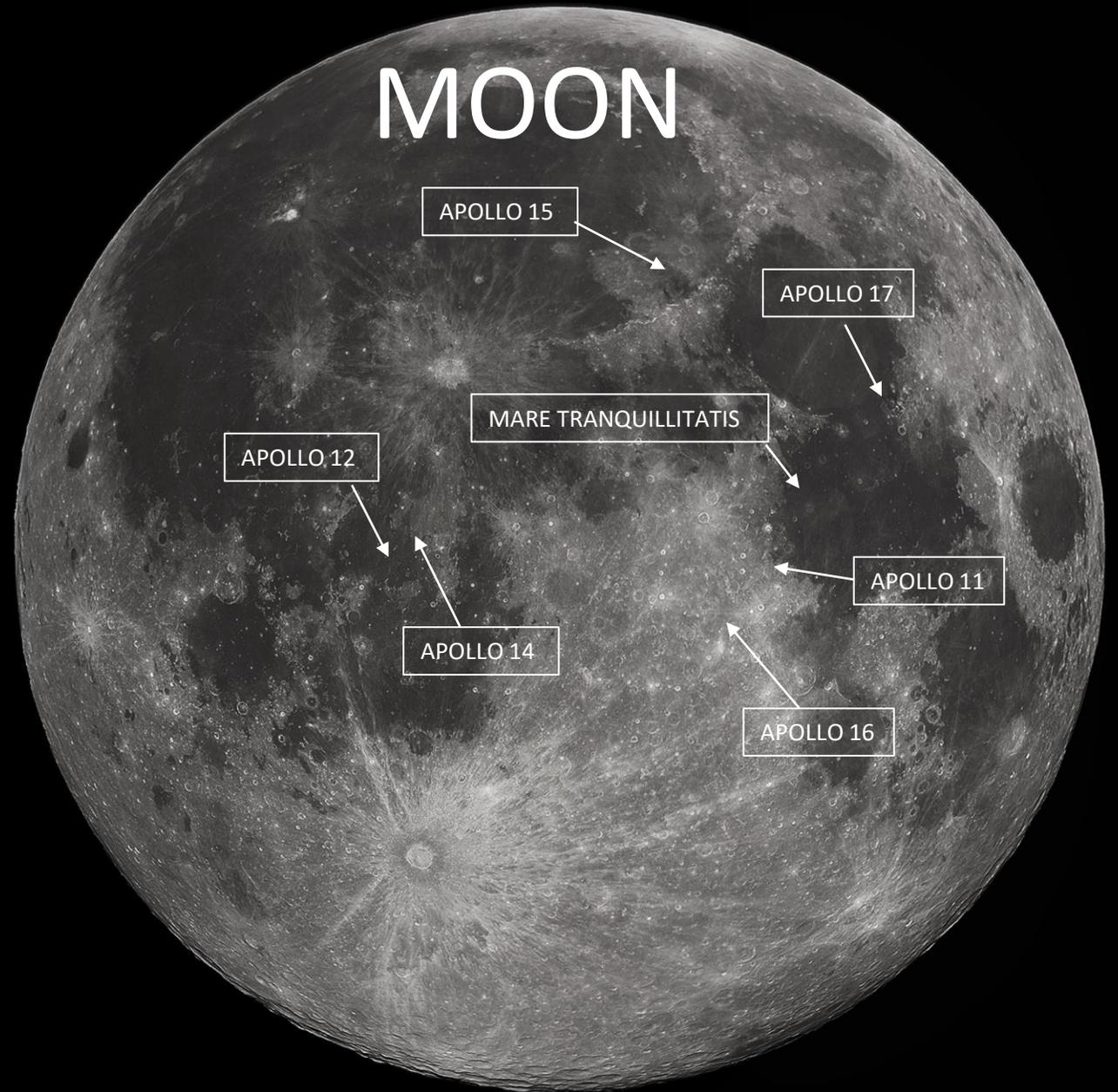


INTERNATIONAL SPACE STATION NASA

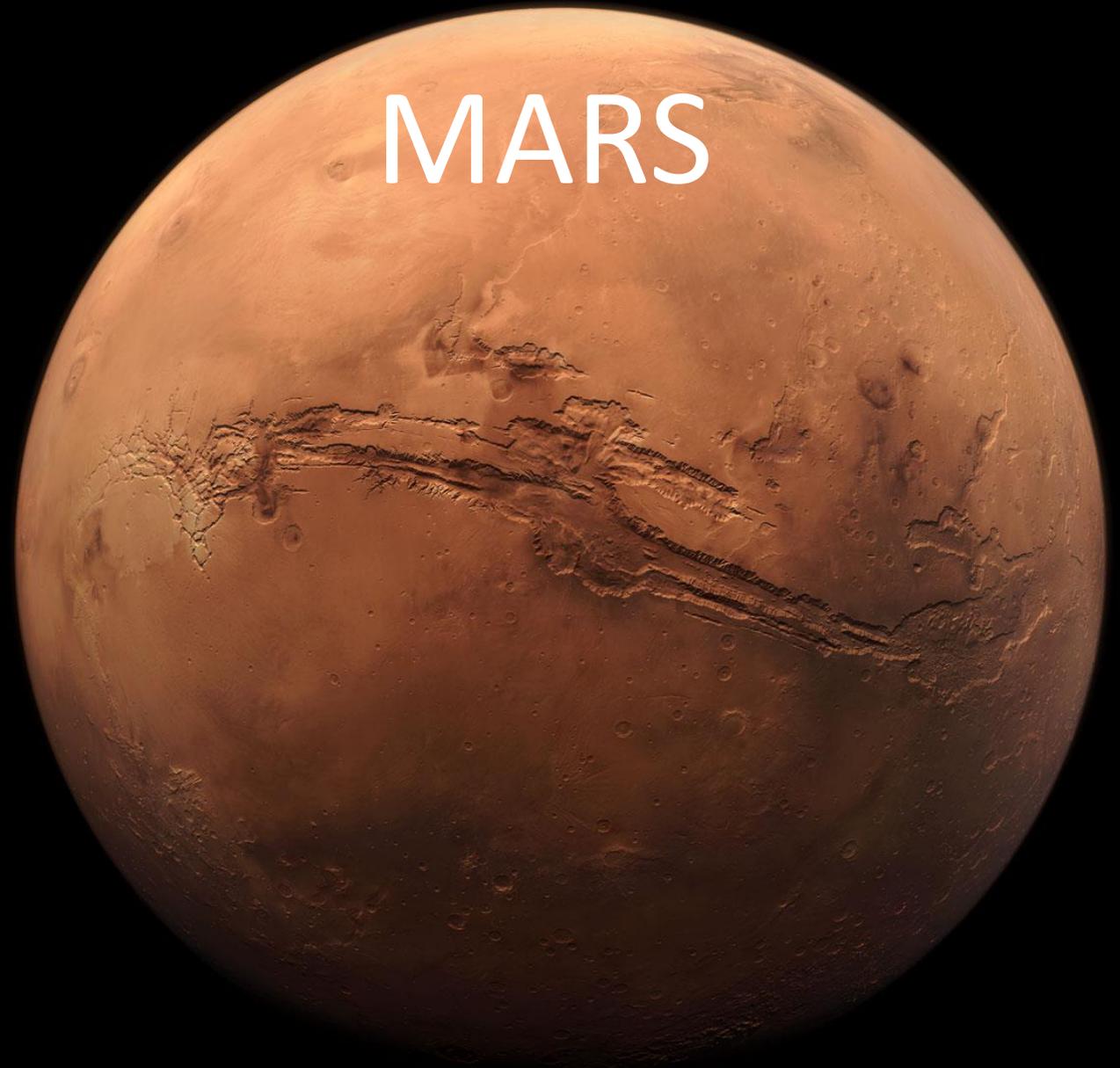


MOON

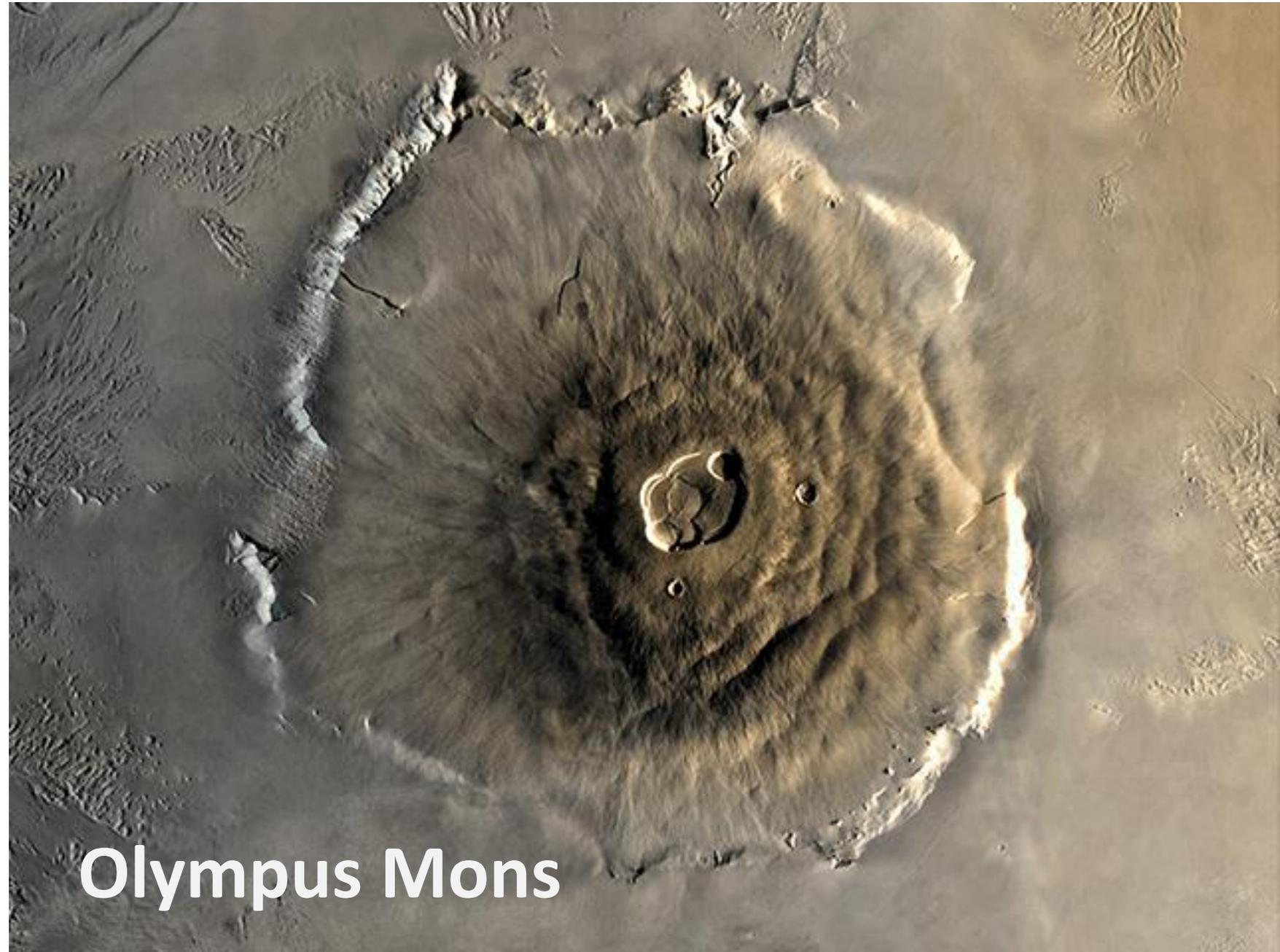
- The Moon is Earth's only natural satellite and the fifth largest moon in the solar system.
- The Moon's presence helps stabilize our planet's wobble, which helps stabilize our climate.
- The Moon's distance from Earth is about 240,000 miles.
- The Moon's entire surface is cratered and pitted from impacts.
- Due to the Moon's tidal gravitational lock with the Earth it rotates with one side facing the Earth.



- Mars has a diameter 4222 miles
- Its 142 million miles from the Sun
- The angular width of the Sun from Mars is half the width as on Earth.
- Valles Marineris is a system of canyons that spans 2,500 miles (19% of circumference). At some points, the canyon is 125 miles wide and 4.4 miles deep.
- Olympus Mons the tallest mountain in the solar system 70,000 feet.
- Mars has the largest dust storms in the solar system.

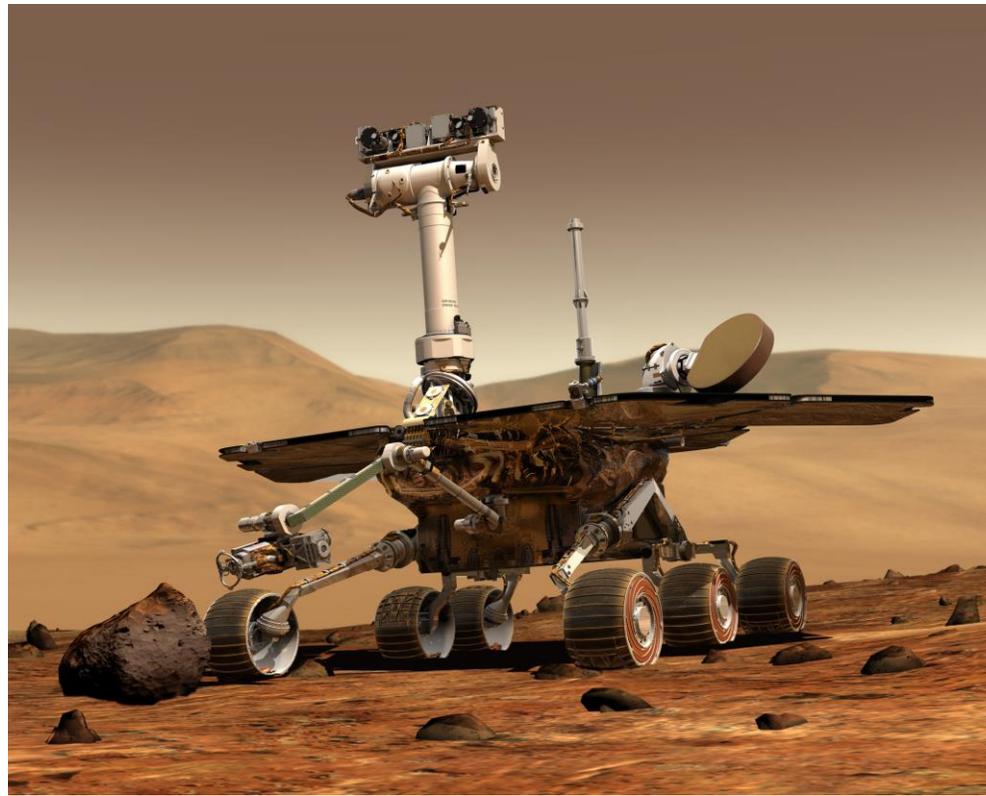


- The largest of the volcanoes in the Tharsis Montes region, as well as all known volcanoes in the solar system, is Olympus Mons.
- Olympus Mons is a shield volcano 374 miles in diameter and 13 miles high.
- Structures of this type are large, dome-shaped mountains built of lava flows. Their name derives from their similarity in shape to a warrior's shield lying face up.
- To compare, the largest volcano on Earth is Mauna Loa. Mauna Loa is a shield volcano but only 75 mile across.



Olympus Mons

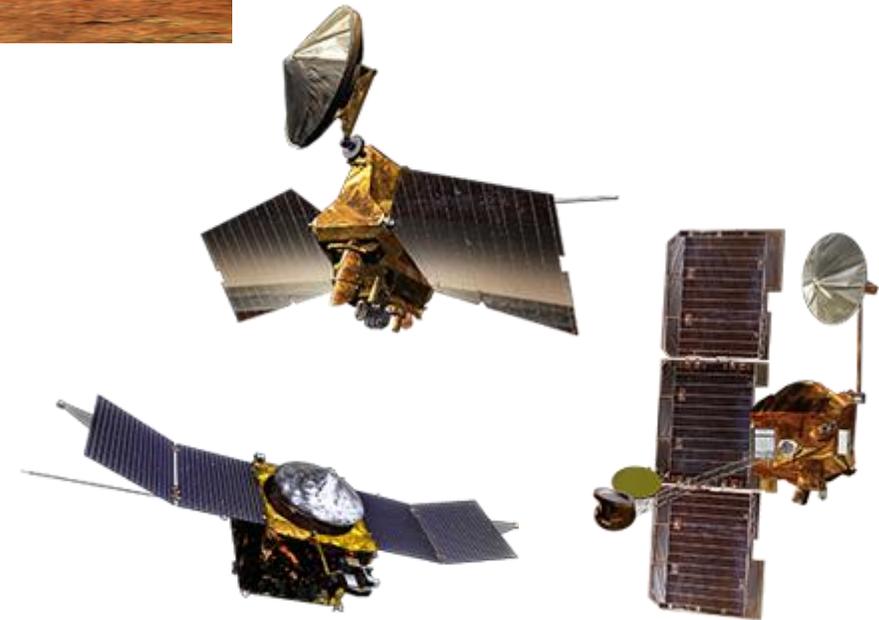
CURIOSITY ROVER

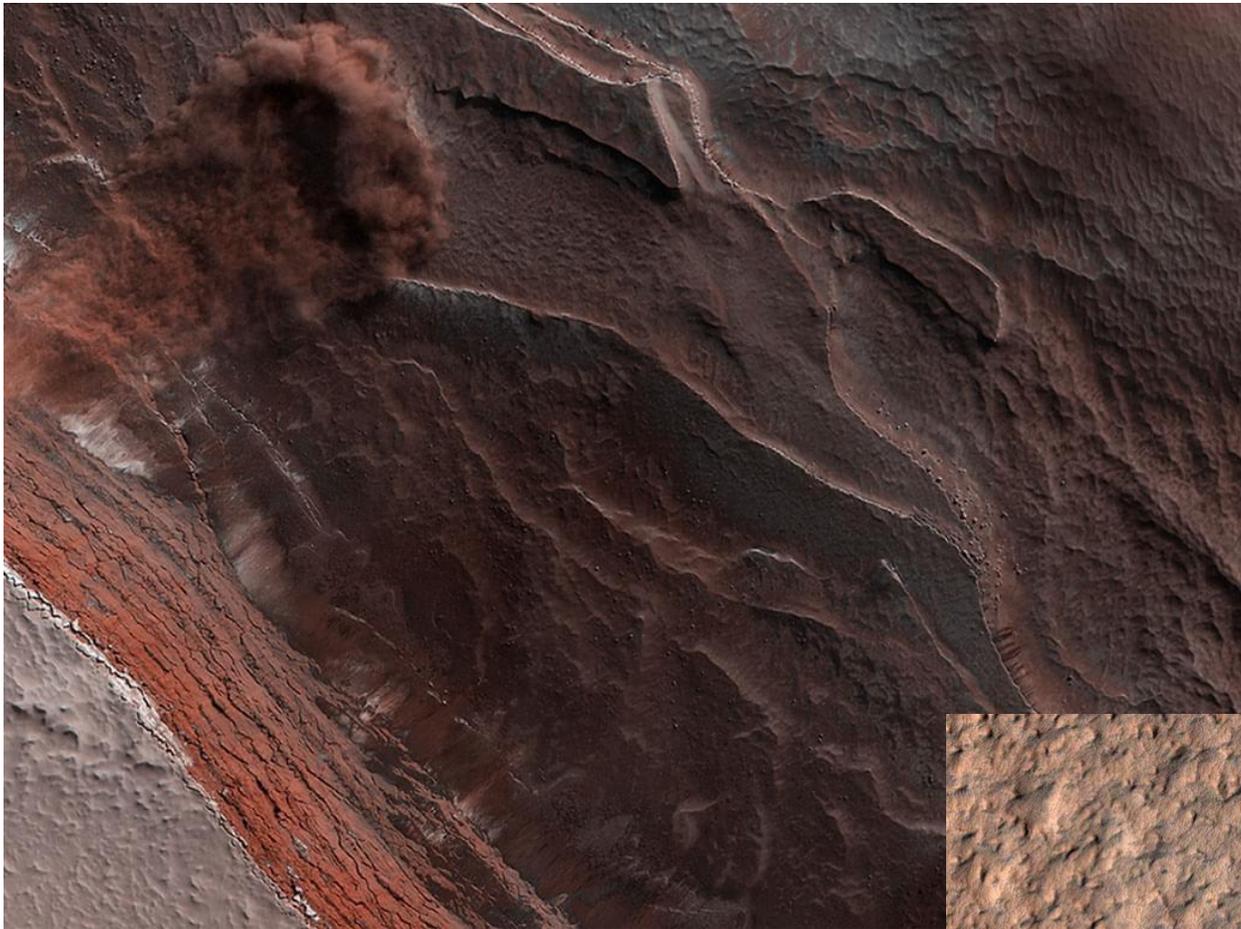


SPiRiT (5 yrs)
& OPPORTUNITY (15 yrs)
ROVERS

- Of 59 mission attempts only 20 have been successful.

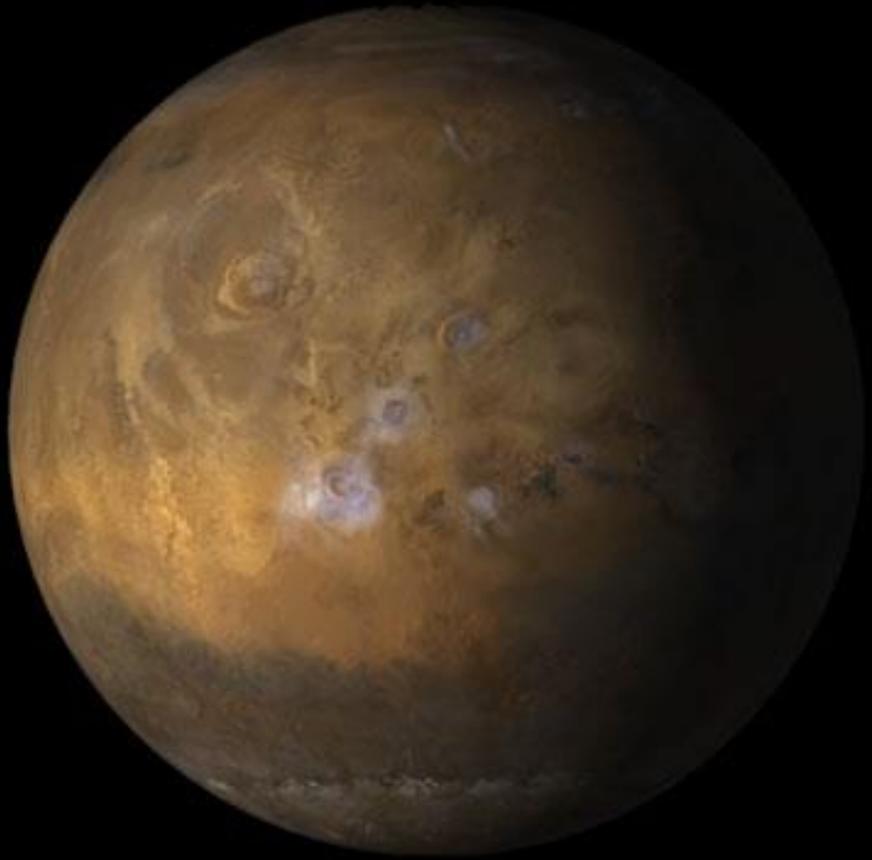
NASA MARS ORBITERS
ODYSSEY: 2001
EXPRESS: 2003
RECONNAISSANCE: 2006
MAVEN: 2014





IMAGES FROM
MARS RECONNAISSANCE
ORBITOR

MARS DUST STORM



May 28



July 1

2018



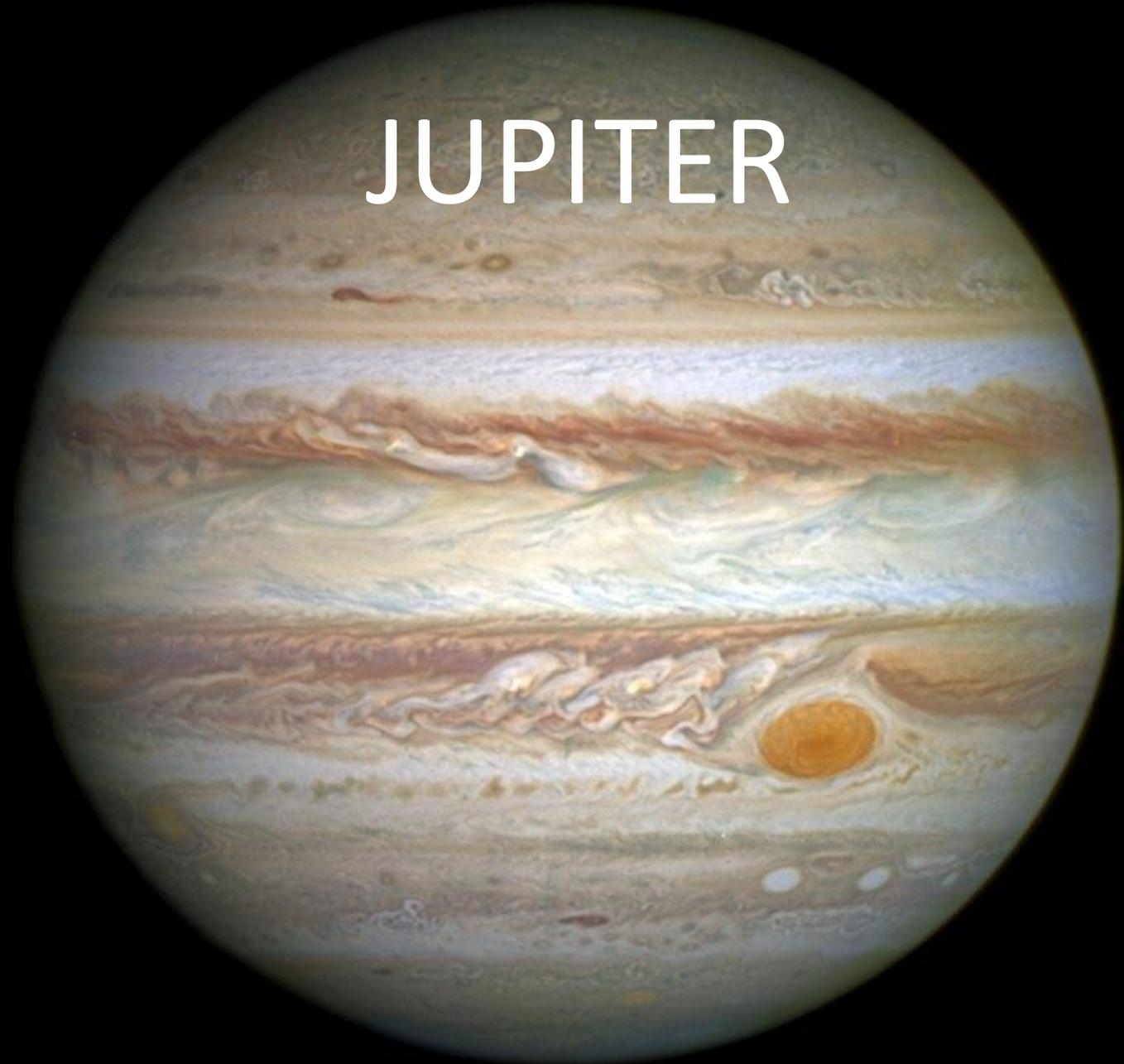
MARS MOONS PHOBOS AND DEIMOS

Mars' moons are among the smallest in the solar system. Phobos is a bit larger than Deimos, and orbits only 3,700 miles above the Martian surface. Deimos orbits 23,436 miles from Mars surface. No known moon orbits closer to its planet. It whips around Mars three times a day, while the more distant Deimos takes 30 hours for each orbit.

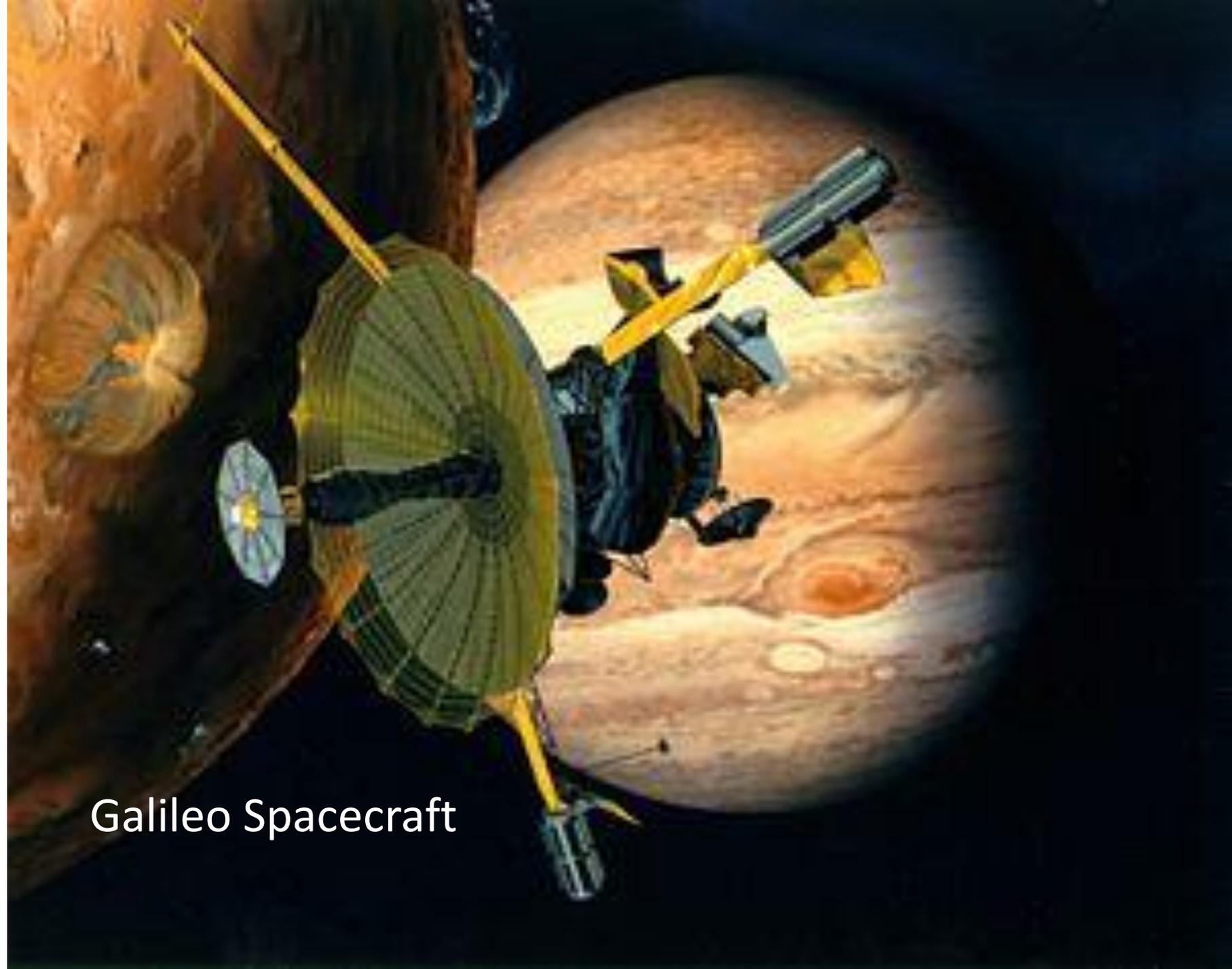
- Asteroids are rocky worlds revolving around the sun between Mars and Jupiter that are too small to be called planets. Asteroids average about 300,000,000 miles from the Sun.
- Asteroids are leftovers from the formation of our solar system about 4.6 billion years ago.
- Jupiter's gravitational pull prevented material in the asteroid belt to bond together and form a planet.
- On occasion an asteroid will be bumped out of orbit and head to earth and become a meteor.
- It is believed that an asteroid 6 to 9 miles in diameter struck earth 66,000 million years ago and ended the reign of the dinosaurs.



- Jupiter orbits about 484 million miles and has a diameter of 80,000 miles
- Jupiter is a gas giant and so lacks an Earth-like surface. If it has a solid inner core at all, it's likely only about the size of Earth.
- Eight spacecraft have visited Jupiter. Seven flew by and two have orbited the gas giant. Juno, the most recent, arrived at Jupiter in 2016.
- Jupiter's Great Red Spot is a gigantic storm that's about twice the size of Earth and has raged for over a century.
- A lot like the Sun, Jupiter is mostly composed of hydrogen and helium. Jupiter contains the largest ocean in the solar system, an ocean of liquid hydrogen.
- Jupiter has 97 moons.



- Launch: Oct. 18, 1989 from Kennedy Space Center, Fla., aboard space shuttle Atlantis.
- Jupiter arrival and orbit insertion: Dec. 7, 1995
- Galileo was the first spacecraft to orbit an outer planet.
- It was the first spacecraft to deploy an entry probe into an outer planet's atmosphere.
- It made the first, and so far only, direct observation of a comet colliding with a planet's atmosphere Shoemaker-Levy 9.



Galileo Spacecraft





JUNO SPACECRAFT

Launched: Aug. 5, 2011

Arrival at Jupiter: July 4, 2016

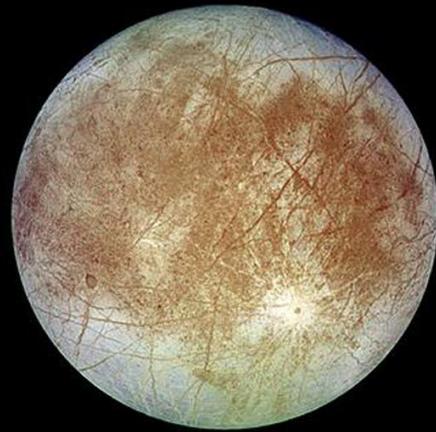
Goal: Understand origin and evolution of Jupiter, look for solid planetary core, map magnetic field, measure water and ammonia in deep atmosphere, observe auroras.

JUPITERS FOUR GALILEAN MOONS

Io



Europa



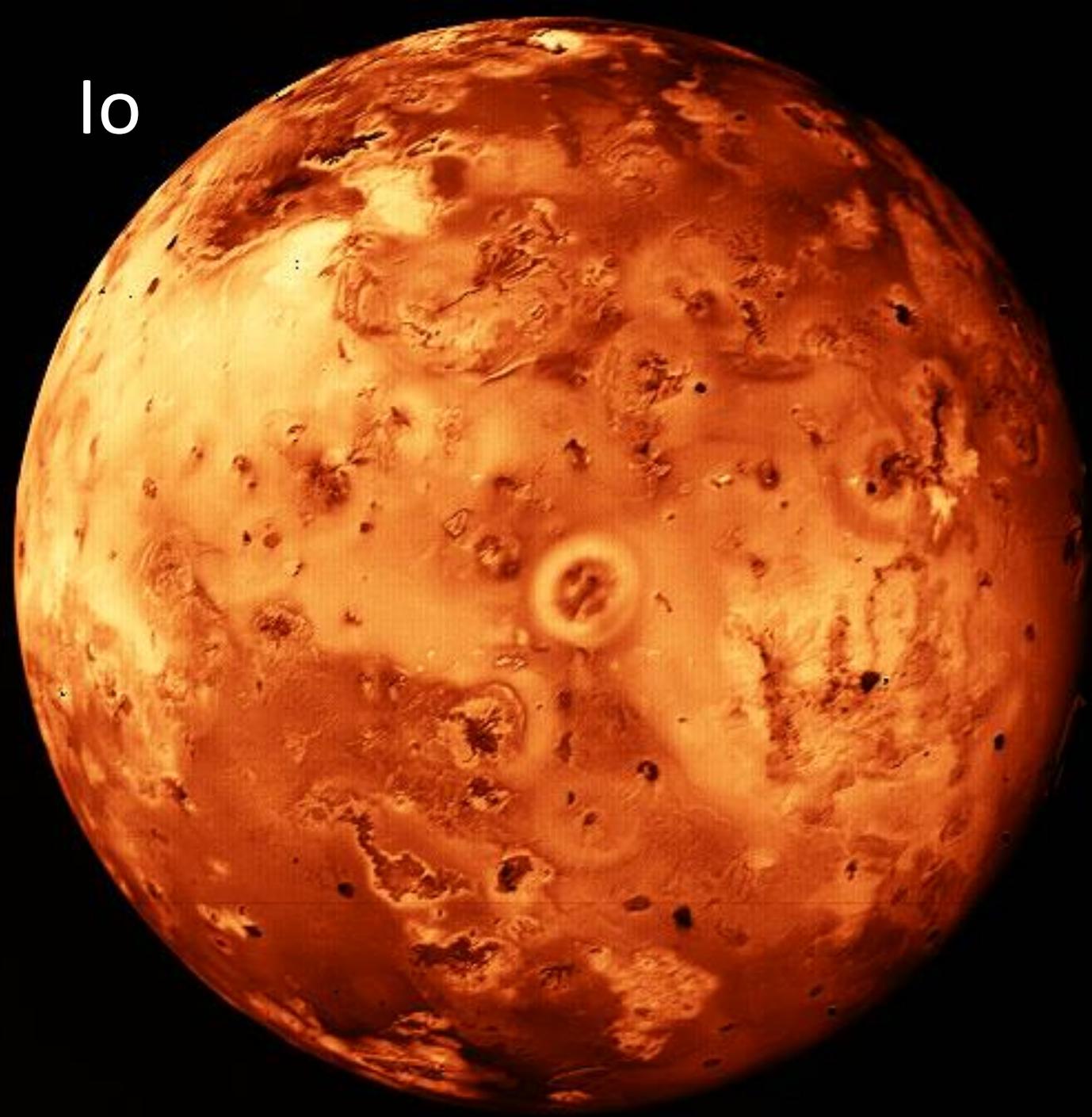
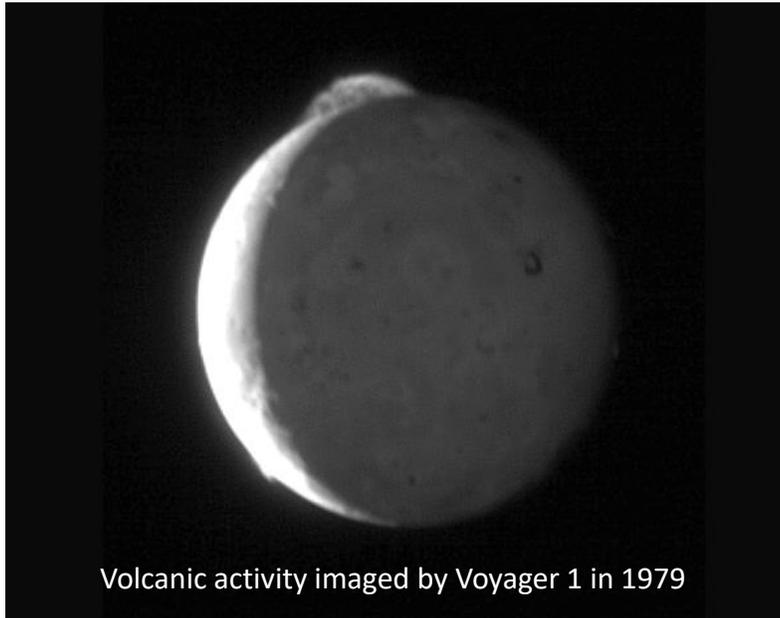
Ganymede



Callisto

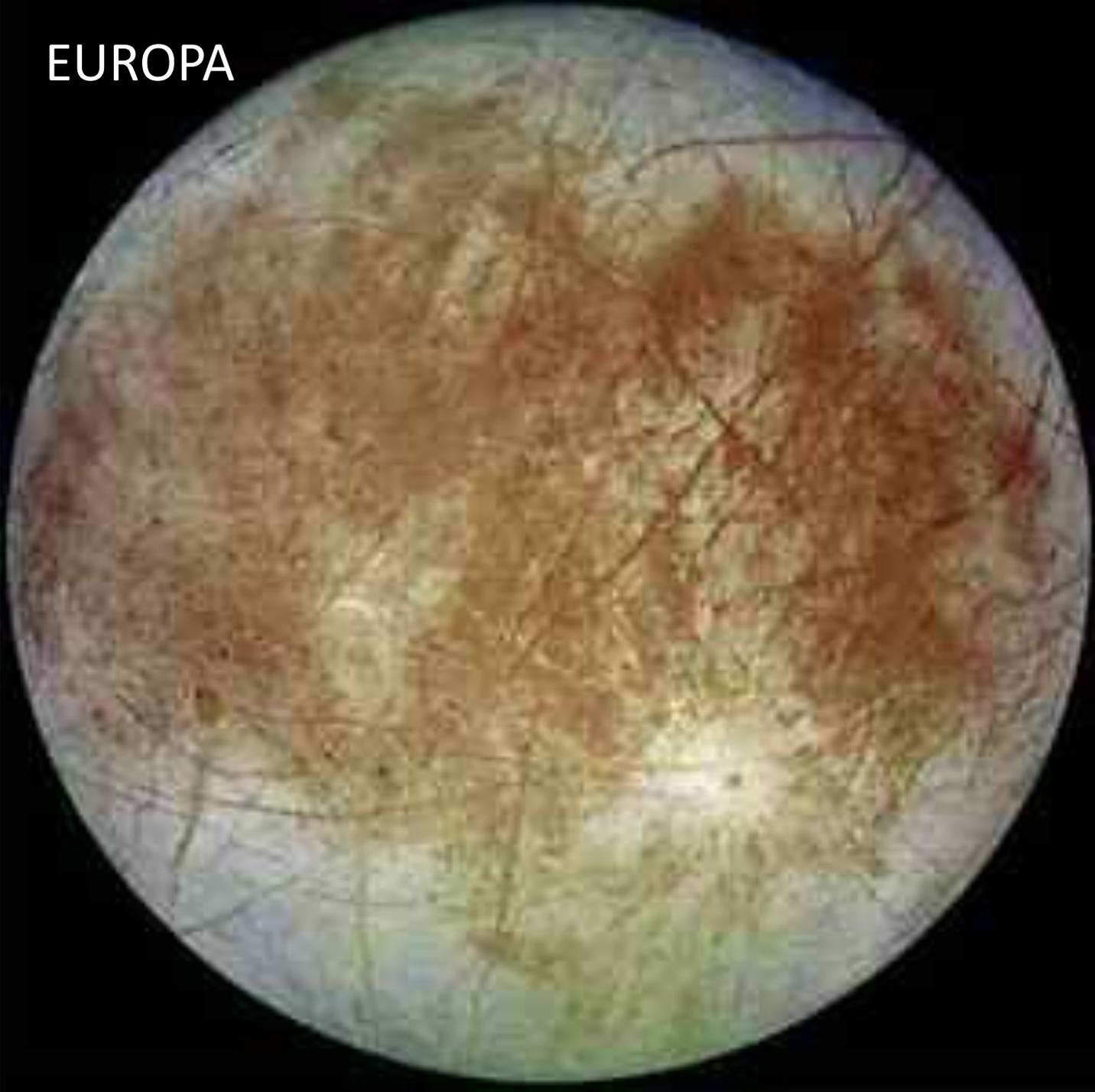


- Io is only slightly larger than Earth's moon and about one-quarter the diameter of Earth itself.
- The moon Io is the most volcanically active world in the solar system. Io even has lakes of molten silicate lava on its surface.
- Spacecraft have studied Io on flybys (*Voyager*) or orbiting Jupiter (*Galileo* & *Cassini*)



EUROPA

- Europa is slightly smaller than Earth's Moon and barely one-quarter the diameter of Earth itself.
- Europa's surface is mostly solid water ice and is crisscrossed by fractures.
- Abundant liquid water, energy and the right chemical elements make Europa one of the best places in the solar system to seek present day life beyond Earth.
- Europa's subsurface ocean might contain more than twice as much water as Earth



GANYMEDE

- Jupiter's moon Ganymede is the largest satellite in the solar system. Larger than Mercury and Pluto, and only slightly smaller than Mars, it would easily be classified as a planet if were orbiting the sun rather than Jupiter.
- It has a diameter of 3,273 mile, making it 26% larger than the planet Mercury by volume.
- Ganymede has a molten core that gives it a magnetic field, a rocky inner core and an icy surface.



CALLISTO

Callisto is a moon of Jupiter with a heavily cratered surface of ice and rock.

Callisto is Jupiter's second largest moon after Ganymede and it's the third largest moon in our solar system.

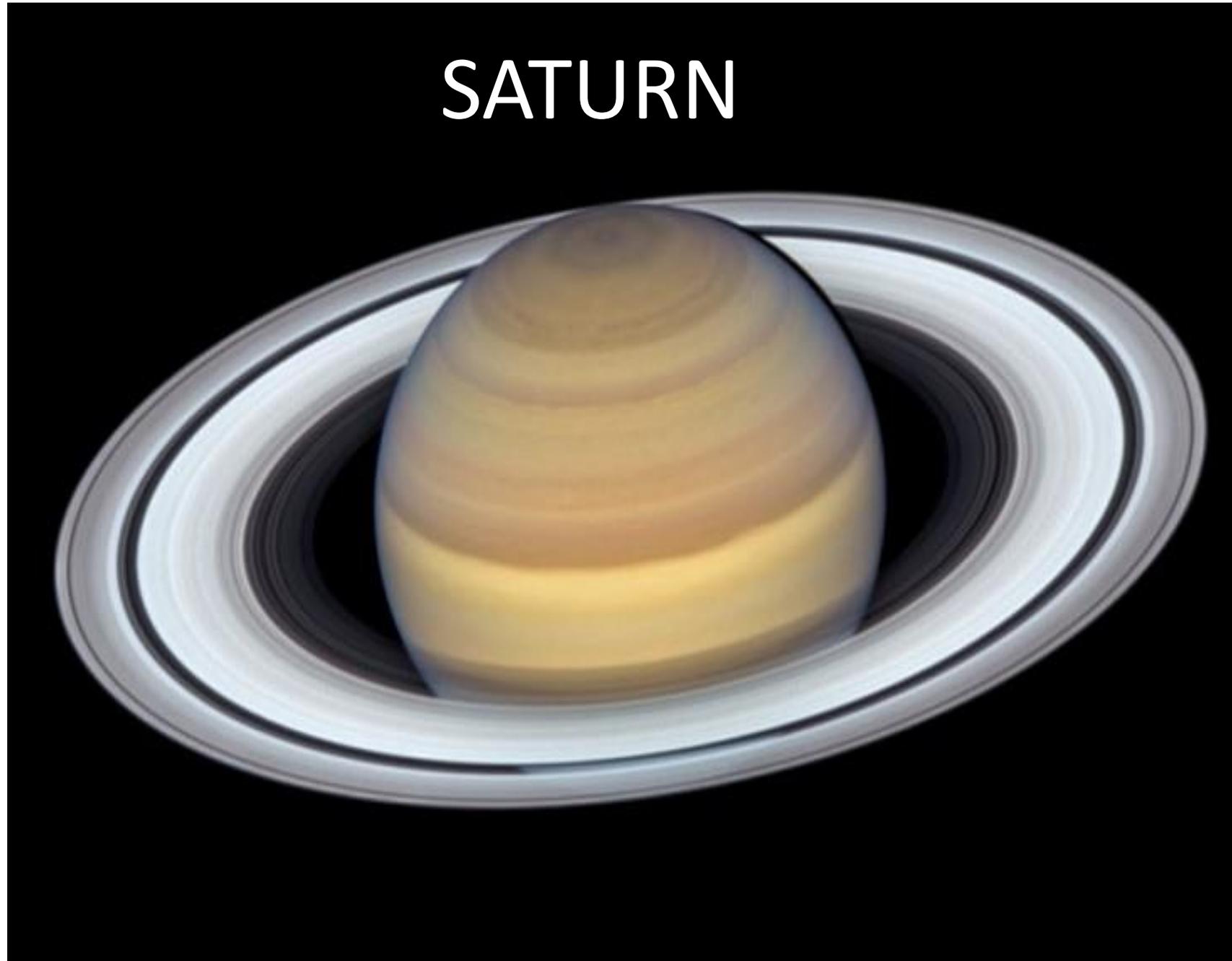
Many NASA spacecraft have observed Callisto including Pioneer, Voyager, Galileo, Cassini, New Horizons, Juno and Hubble.

There is evidence of a subsurface ocean on Callisto, putting Callisto on the list of possible places where life could exist beyond Earth.

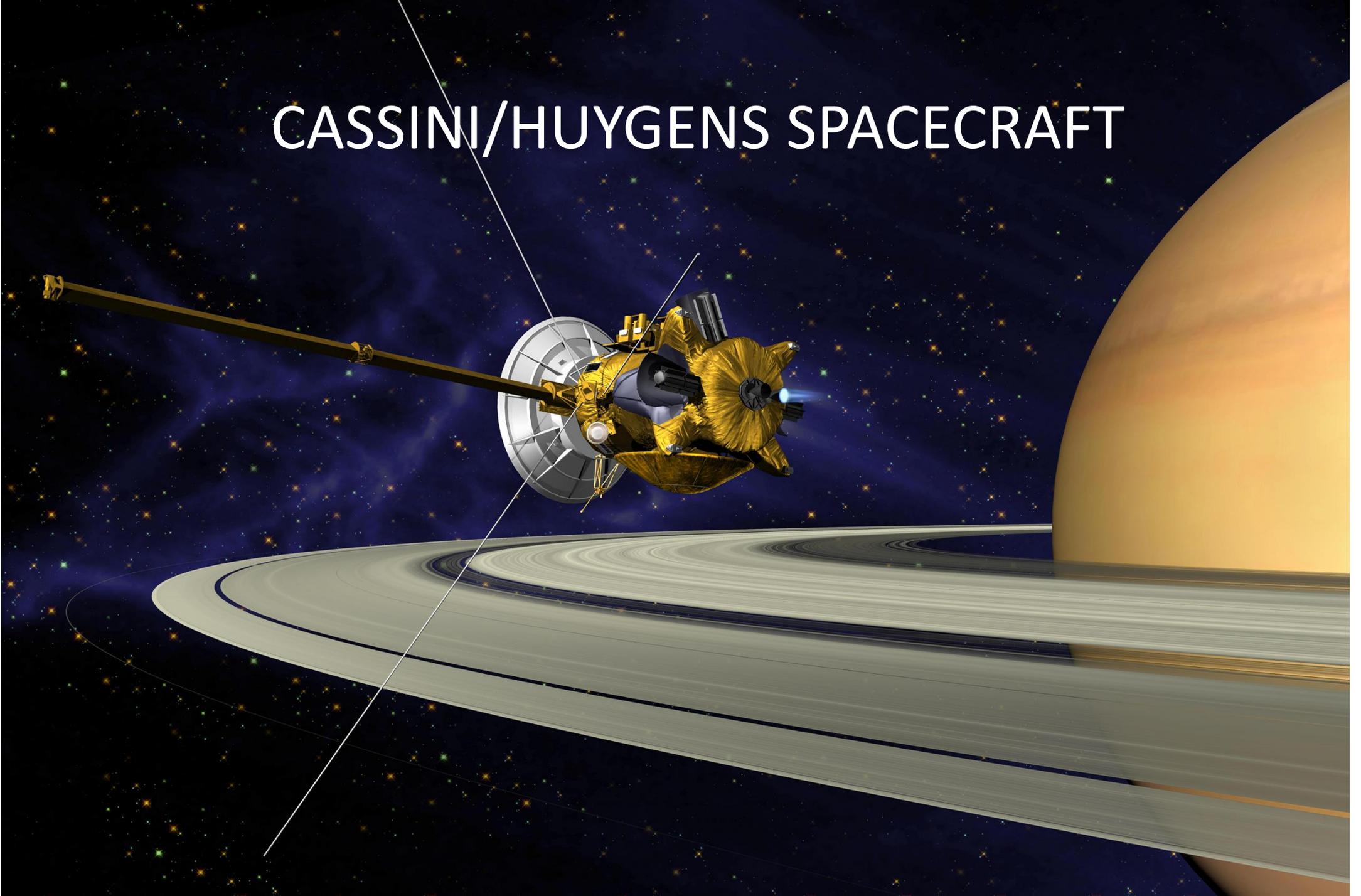


SATURN

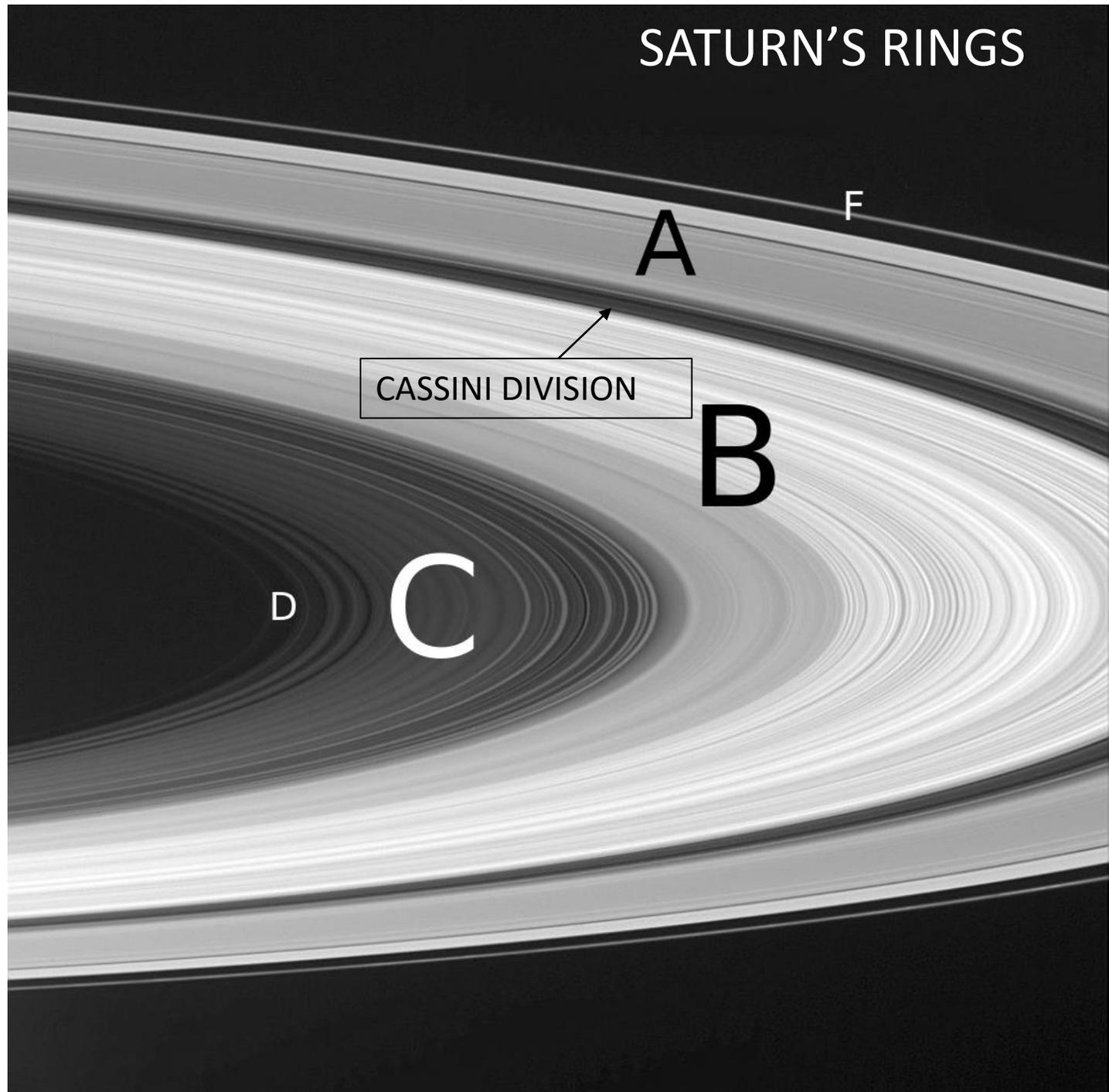
- Saturn is the sixth planet from our Sun and orbits at a distance of about 886 million miles from the Sun.
- Nine Earths side by side would almost span Saturn's diameter. That doesn't include Saturn's rings.
- Saturn is a gas-giant planet and therefore does not have a solid surface like Earth's.
- Saturn has the most spectacular ring system, with seven rings and several gaps and divisions between them.
- Four NASA missions have visited Saturn: Pioneer 11 and Voyagers 1 and 2 flew by; But Cassini orbited Saturn 294 times from 2004 to 2017.
- Saturn has 82 known moons.



CASSINI/HUYGENS SPACECRAFT



- Saturn's rings are thought to be pieces of comets, asteroids or shattered moons that broke up before they reached the planet, torn apart by Saturn's powerful gravity.
- They are made of billions of small chunks of ice and rock coated with another material such as dust.
- Many of Saturn's moons are within the ring system.
- The Cassini Division is so called because Giovanni Cassini discovered it at the Paris Observatory in 1675.
- The dense main rings extend from 4,300 mi to 50,000 mi away from Saturn's equator. With an estimated local thickness of as little as 10 m and as much as 1 km, they are composed of 99.9% pure water **ice**. The main rings are primarily composed of particles ranging in size from 1 cm to 10 m.



TITAN

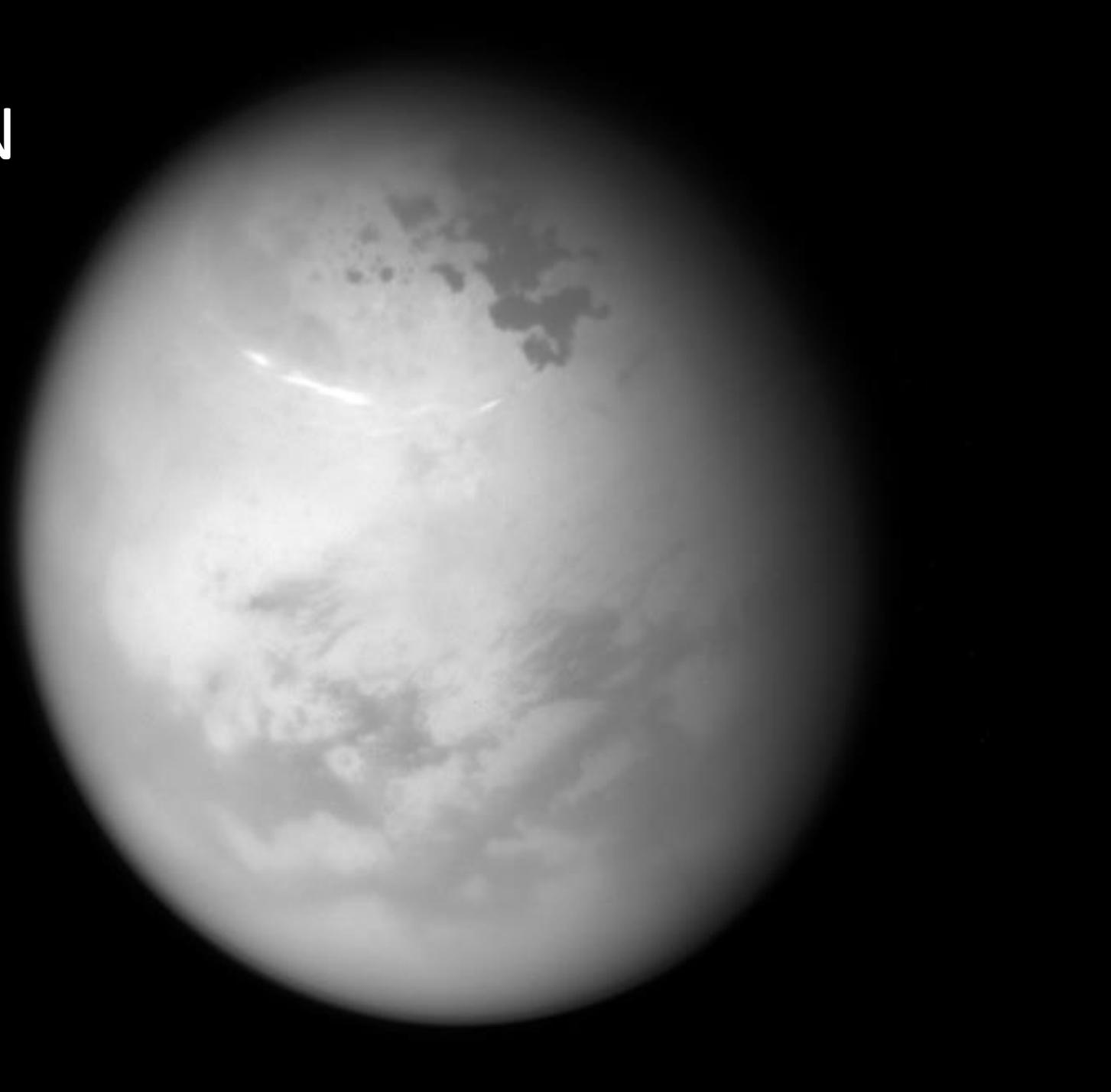
Saturn's largest moon Titan is the second largest moon in the solar system. It is bigger than planet Mercury.

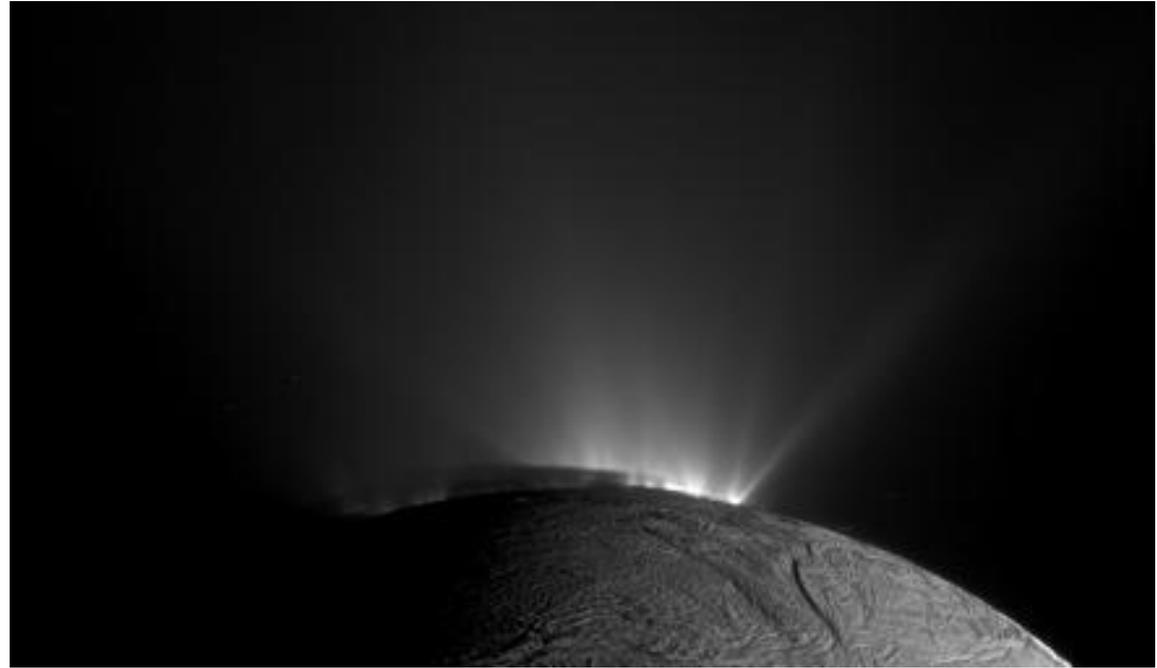
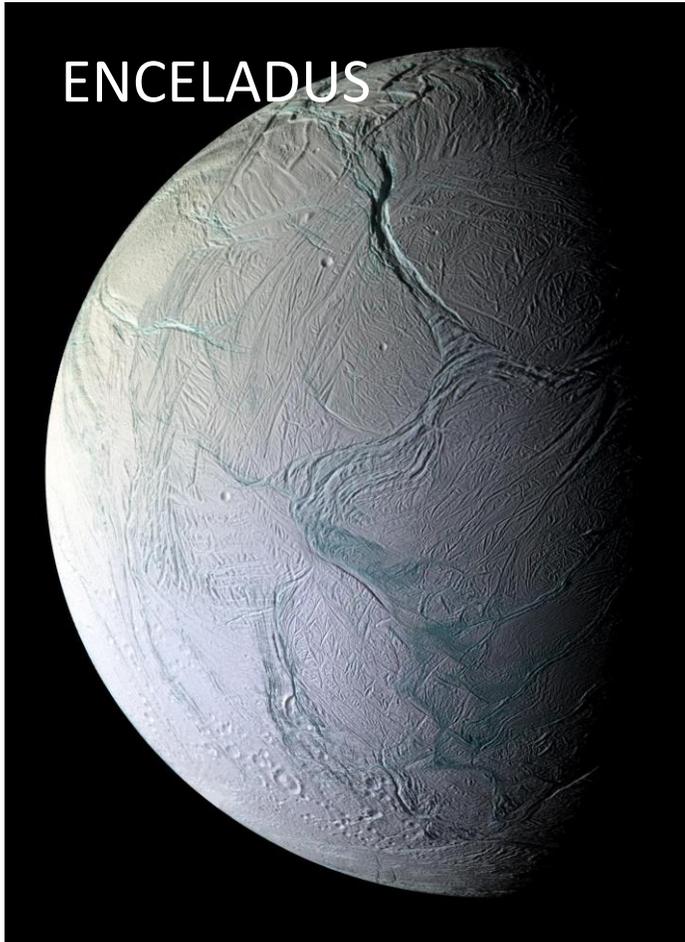
The same side of Titan always faces Saturn, so Titan takes 16 days to orbit Saturn and to rotate once.

Titan is an icy moon with a surface of rock-hard water ice, but Titan also likely has a liquid water ocean beneath its surface.

Titan has clouds, rain, rivers, lakes and seas of liquid hydrocarbons like methane and ethane.

Titan's subsurface water could be a place to harbor life as we know it.





NASA's Cassini spacecraft captured this image of Enceladus on Nov. 30, 2010. The shadow of the body of Enceladus on the lower portions of the jets is clearly visible. Image Credit: NASA/JPL-Caltech/Space Science Institute

Enceladus is about as wide as Arizona and also has the whitest, most reflective surface in the solar system. The moon creates a ring of its own as it orbits Saturn—its spray of icy particles spreads out into the space around its orbit, circling the planet to form Saturn's E ring.

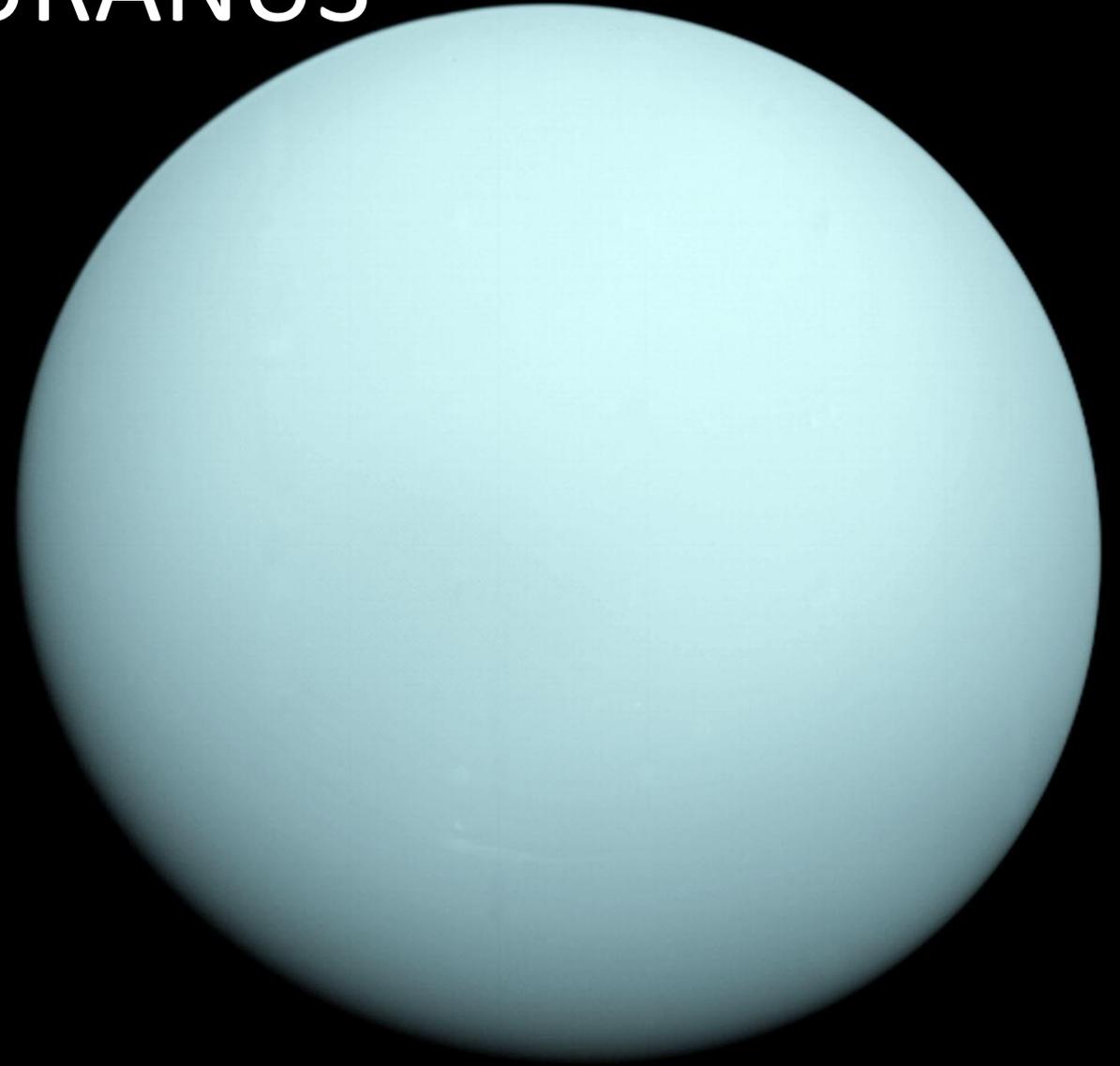
MIMAS

- Mimas was discovered on Sept. 17, 1789 by English astronomer William Herschel, using his 40-foot reflector telescope.
- Ground-based astronomers could only see Mimas as little more than a dot until Voyagers I and II imaged it in 1980.
- The Cassini spacecraft made several close approaches and provided detailed images of Mimas.
- Less than 123 miles in mean radius, crater-covered Mimas is the smallest and innermost of Saturn's major moons. I

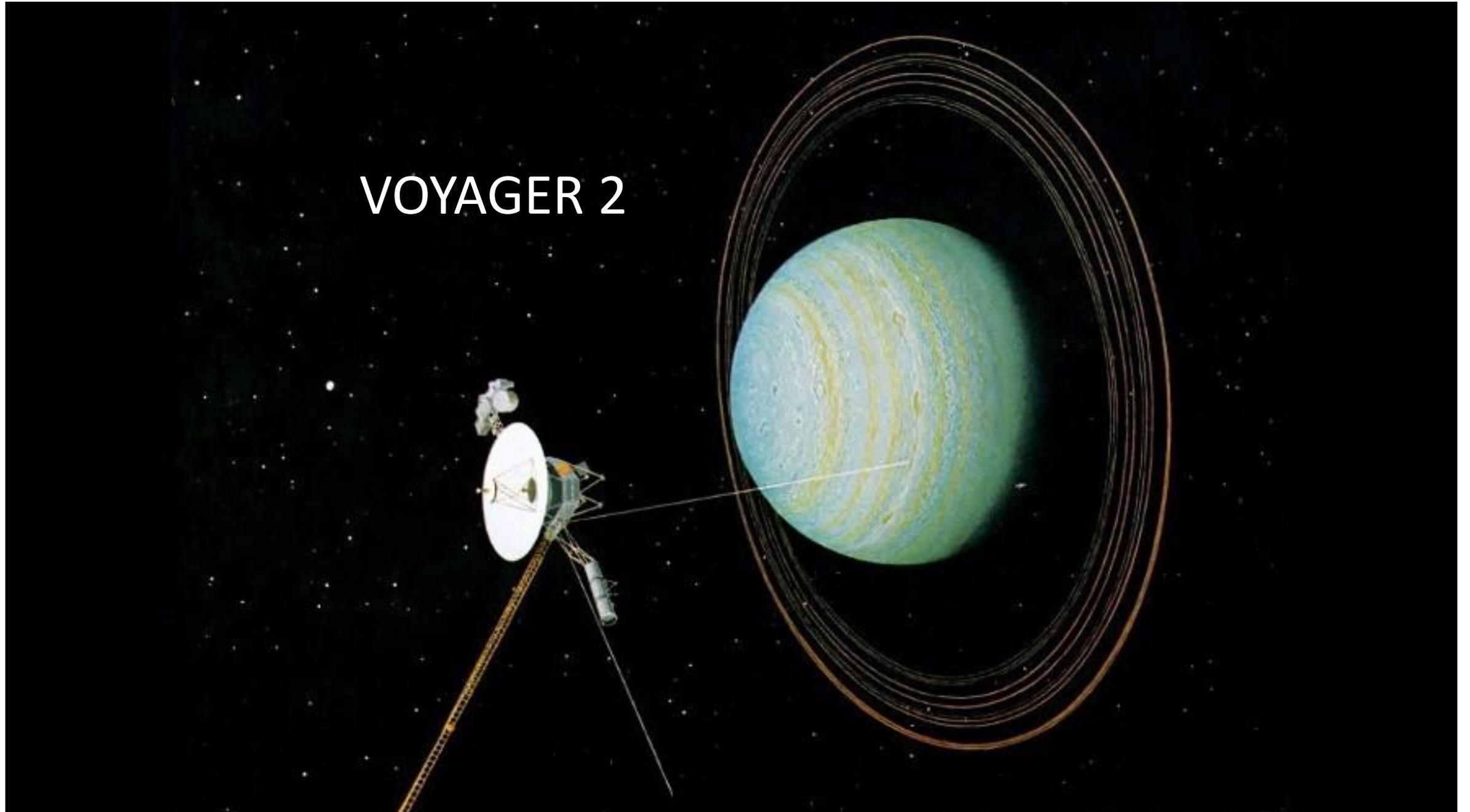


- Uranus is known as the “sideways planet” because it rotates on its side. 1.8 billion miles from the sun.
- Uranus was discovered in 1781 by William Herschel.
- Uranus was the first planet found using a telescope. 1.8 billion miles from the sun.
- Uranus is an Ice Giant planet and nearly four times larger than Earth.
- Uranus has 27 known moons, most of which are named after literary characters.
- Like Saturn, Jupiter and Neptune, Uranus is a ringed planet
- Voyager 2 is the only spacecraft to fly by and collect data from Uranus.
- Uranus is also one of just two planets that rotate in the opposite direction than most of the planets (Venus is the other one), from east to west.

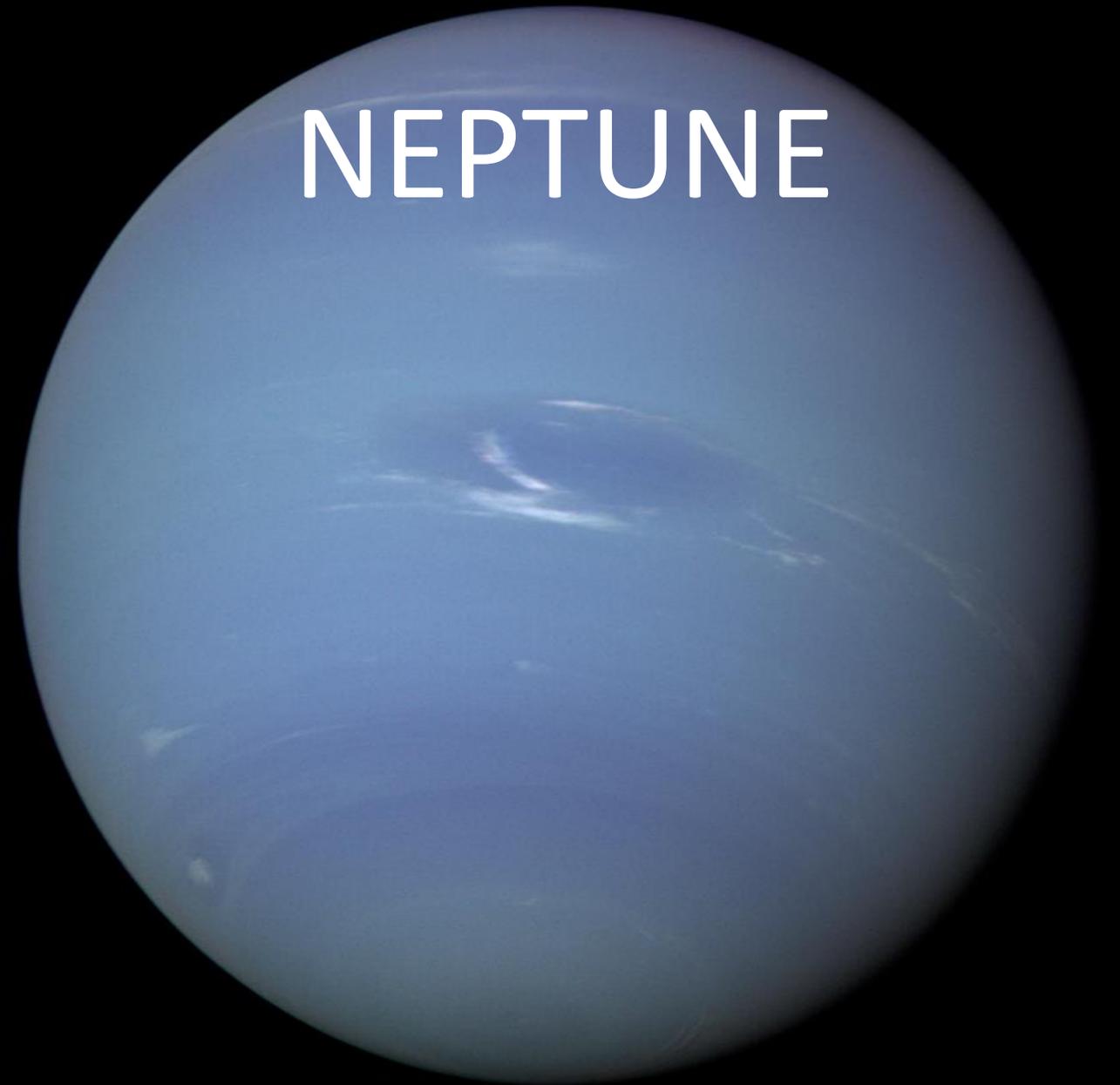
URANUS



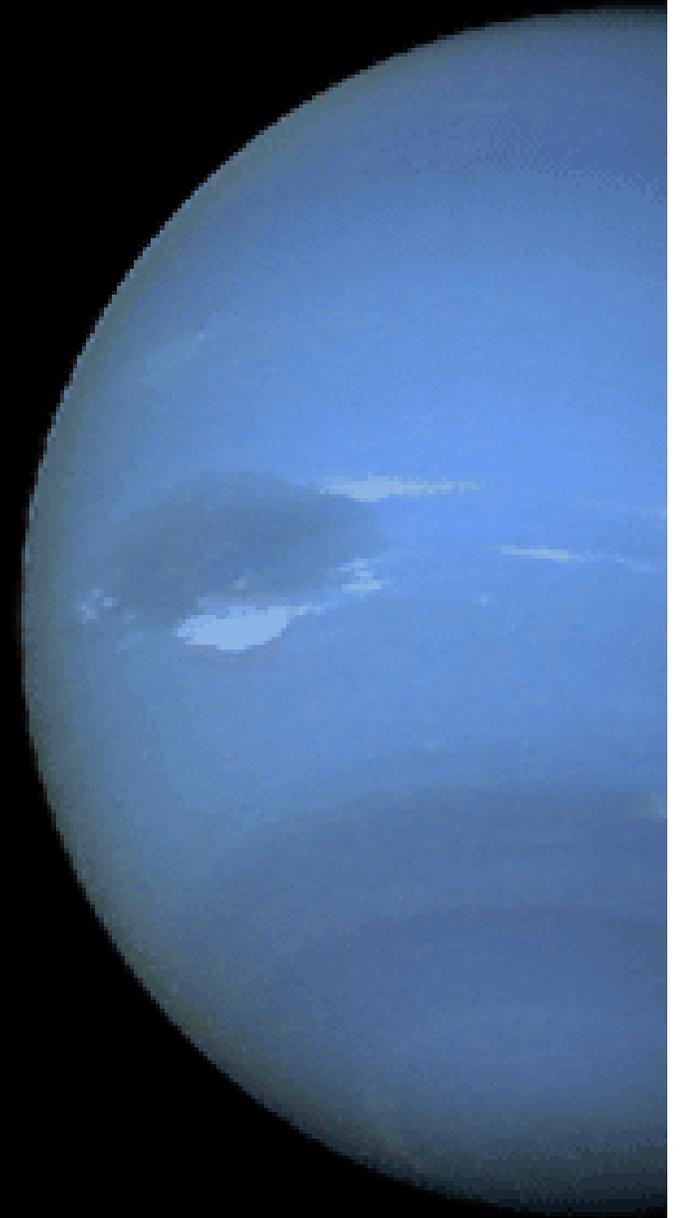
VOYAGER 2



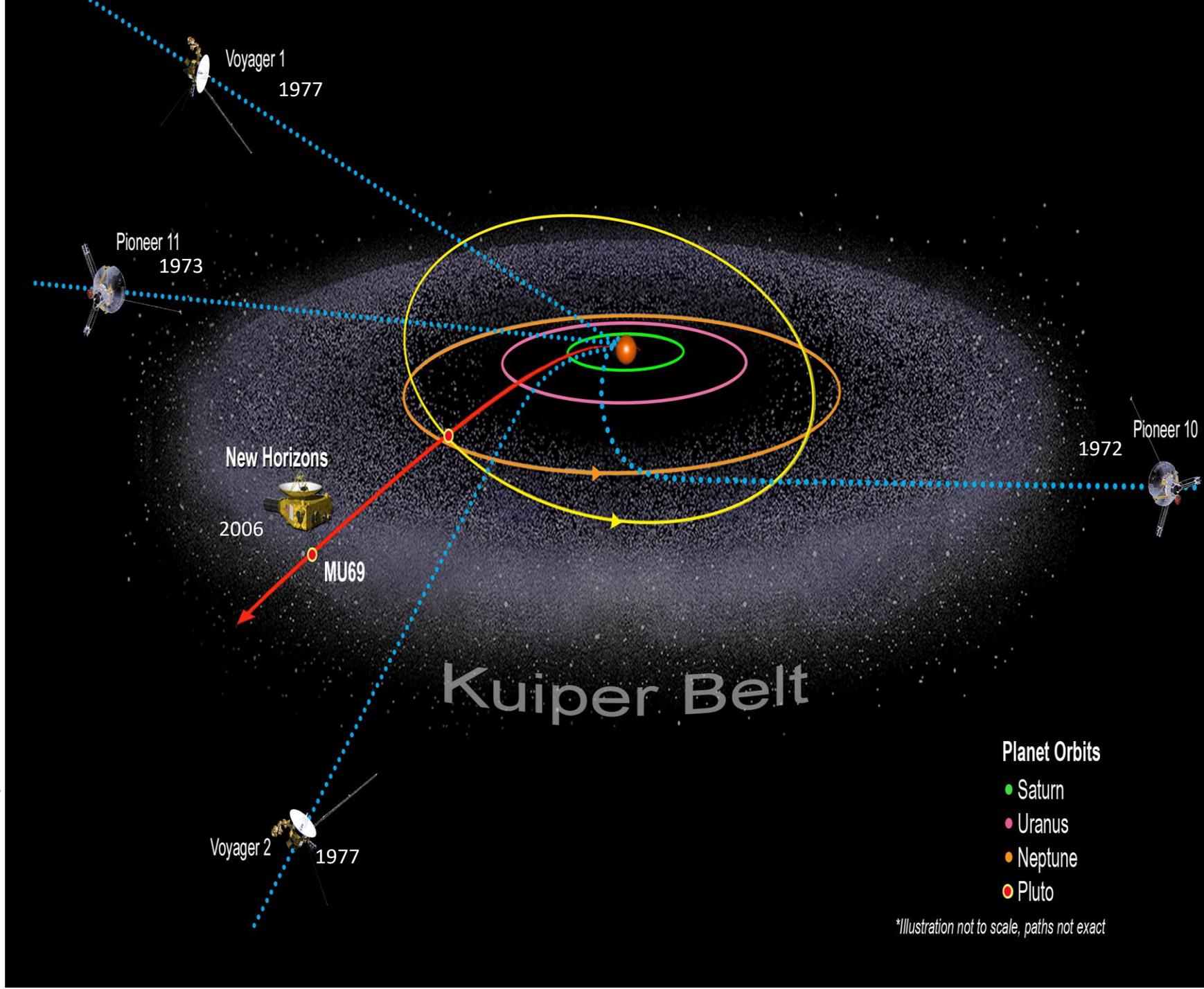
- Neptune orbits our Sun and is the eighth planet from the Sun at a distance of about 2.8 billion miles.
- Voyager 2 is the only spacecraft to have visited Neptune. No spacecraft has orbited this distant planet to study it at length and up close.
- Neptune has 14 moons.
- Neptune is an ice giant. Most of its mass is a hot, dense fluid of "icy" materials – water, methane and ammonia – above a small rocky core.
- Neptune's atmosphere is made up mostly of molecular hydrogen, atomic helium and methane.



VOYAGER 2



- The first mission to explore the Kuiper Belt is New Horizons. It flew past Pluto in 2015 and is on its way to explore another Kuiper Belt world.
- The Kuiper Belt is a region of space known for its icy worlds and comets.
- The Kuiper Belt is a doughnut-shaped ring of icy objects around the Sun, extending just beyond the orbit of Neptune from about 30 to 55 AU.
- Several dwarf planets have been identified within the Kuiper Belt. A few are Pluto, Eris, Makemake, Haumea, Orcus. Each of these have at least one moon.



PLUTO

- Pluto is a dwarf planet in the Kuiper Belt.
- Pluto is only about 1,400 miles wide. At that small size, Pluto is only about half the width of the United States.
- Pluto is about 3.6 billion miles away from the Sun and has five moons.
- Pluto's atmosphere is thin and composed mostly of nitrogen, methane and carbon monoxide.
- Pluto and its largest moon, Charon, are so similar in size that they orbit each other like a double planet system.
- On average, Pluto's temperature is -387°F (-232°C), making it too cold to sustain life, but it does have a heart-shaped glacier bigger than Texas.

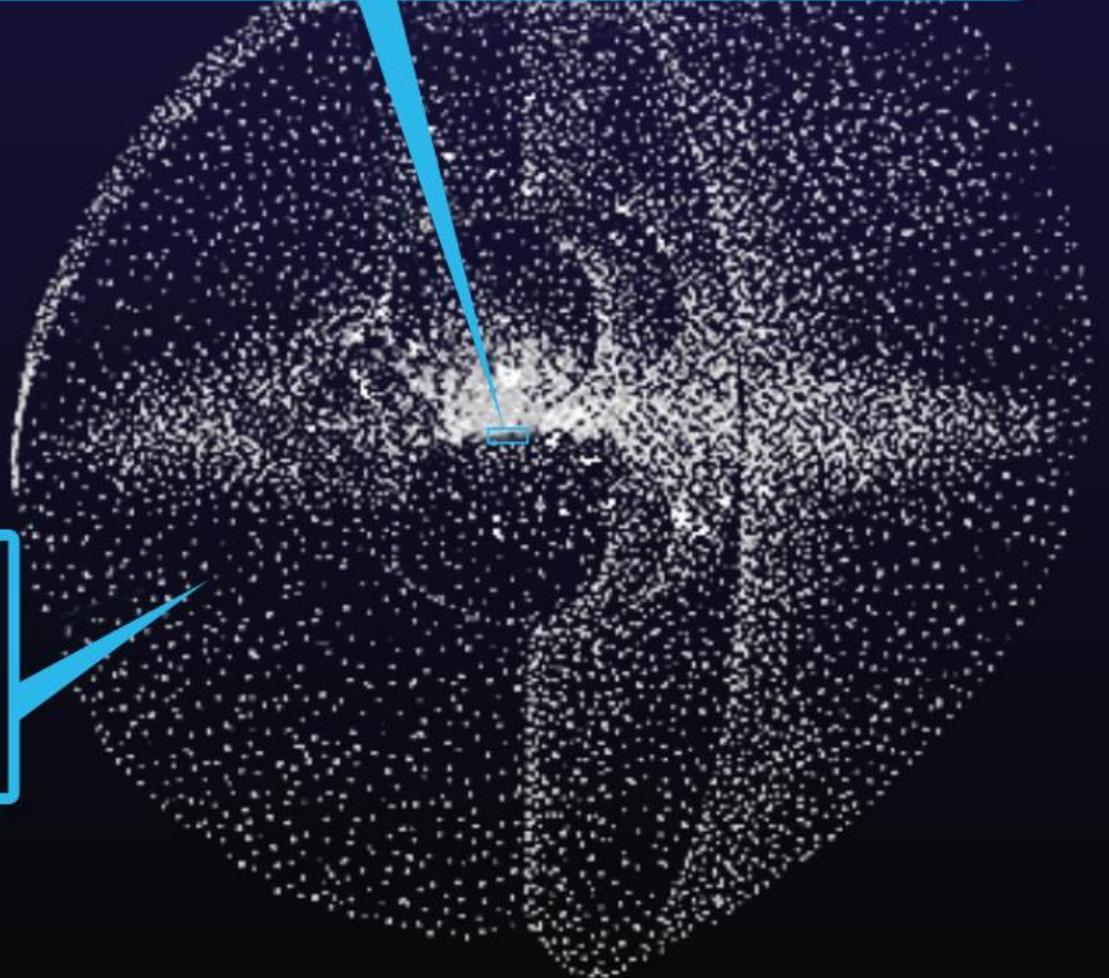
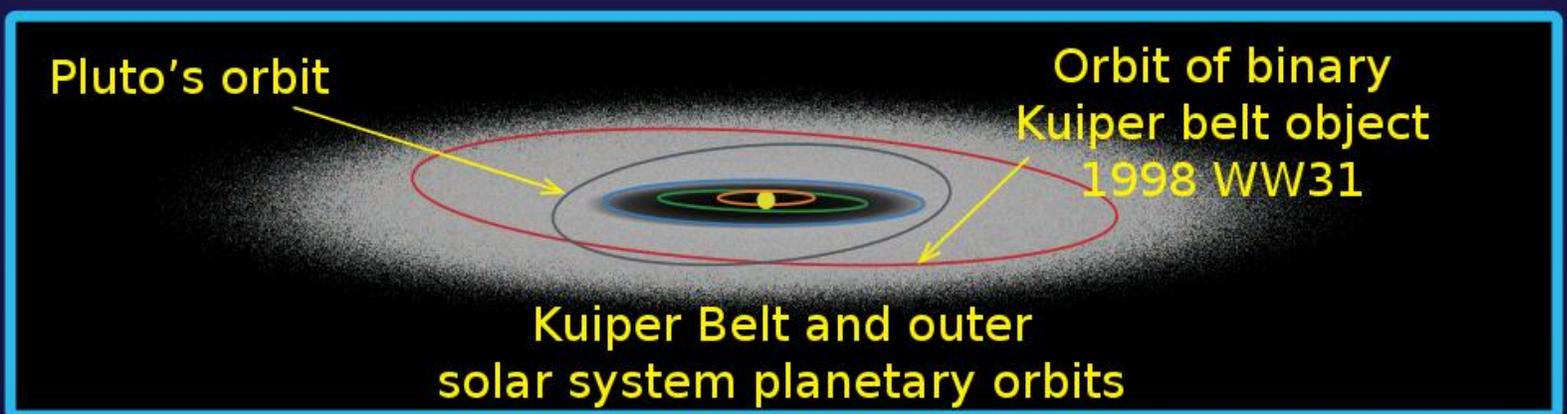


- On July 14, 2015, NASA's New Horizons spacecraft made its historic flight through the Pluto system – providing the first close-up images of Pluto and its moons and collecting other data that has transformed our understanding of these mysterious worlds on the solar system's outer frontier.
- It took 10 years for New Horizons to reach Pluto and went by at 38,000 mph.



The Oort Cloud is a predicted collection of icy objects farther away than everything else in the solar system.

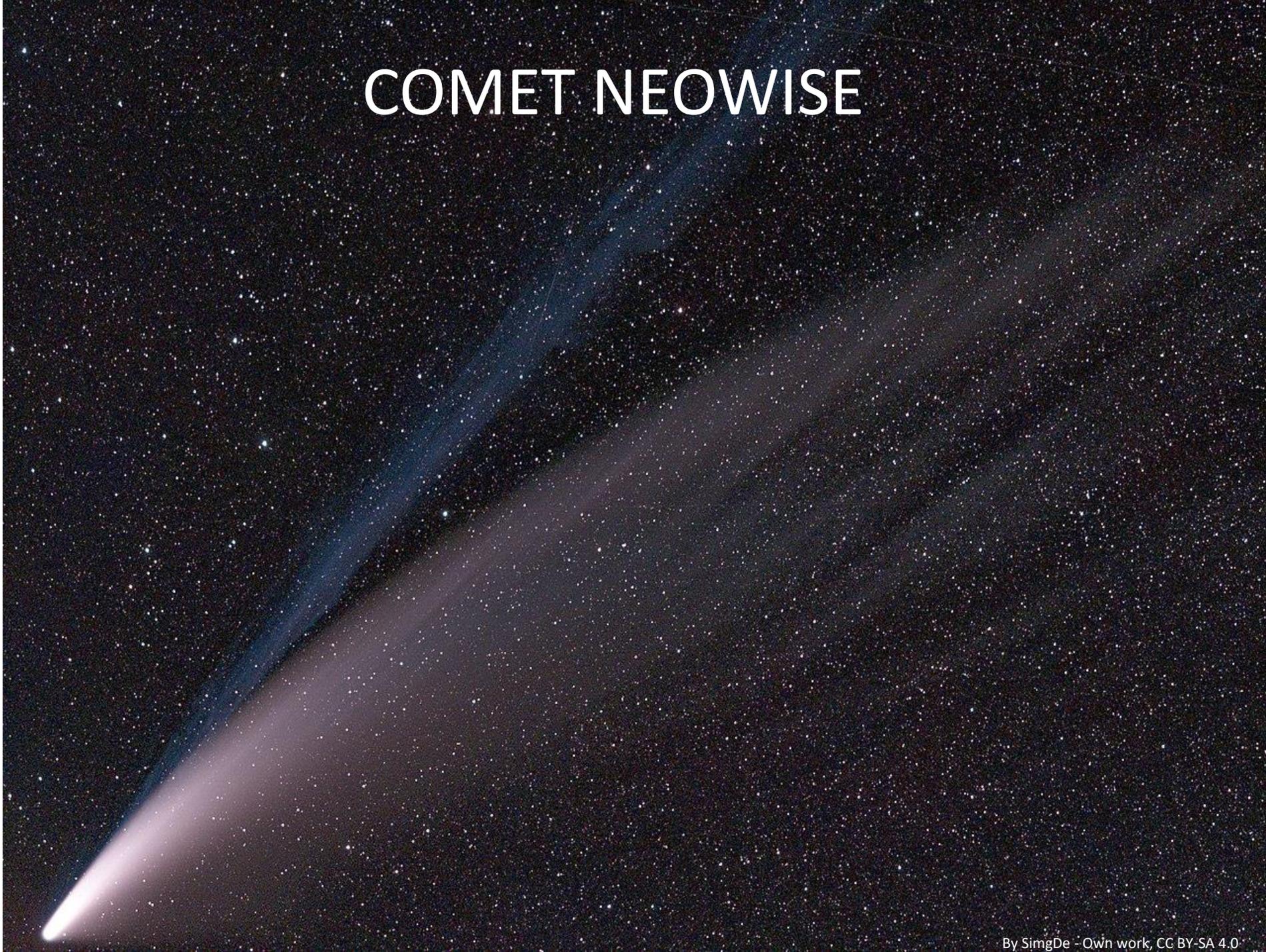
The Oort Cloud is a spherical layer of icy objects surrounding our Sun and likely occupies space at a distance between about 2,000 and 100,000 astronomical units (AU) from the Sun.



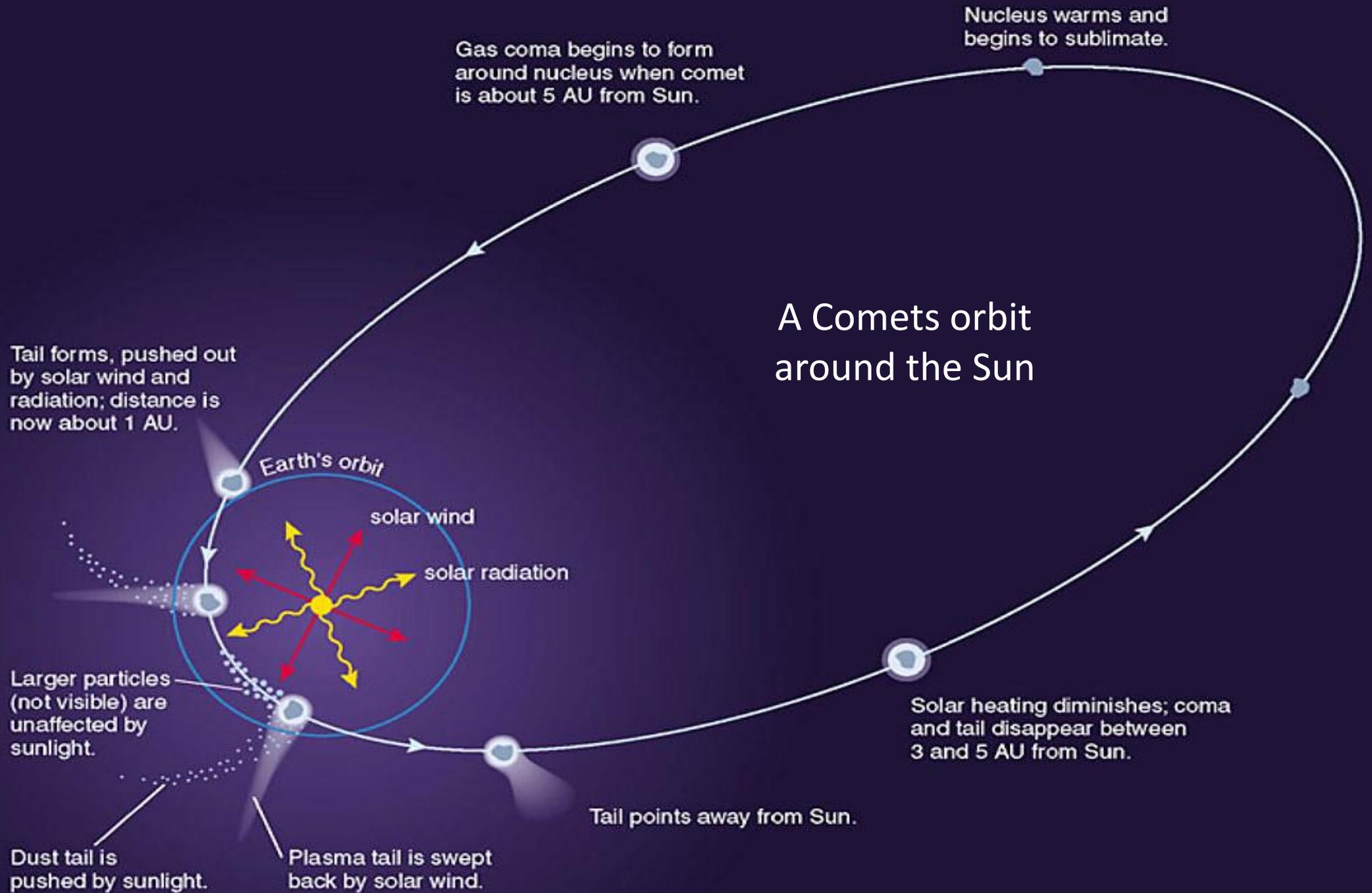
**The Oort cloud
(comprising many
billions of comets)**

- Comets are frozen leftovers from the formation of the solar system composed of dust, rock and ices.
- They range from a few miles to tens of miles wide, but as they orbit closer to the sun, they heat up and spew gases and dust into a glowing head that can be larger than a planet.
- This material forms a tail that stretches millions of miles.
- The Neowise is a long period comet that will not return for another 6700 years,

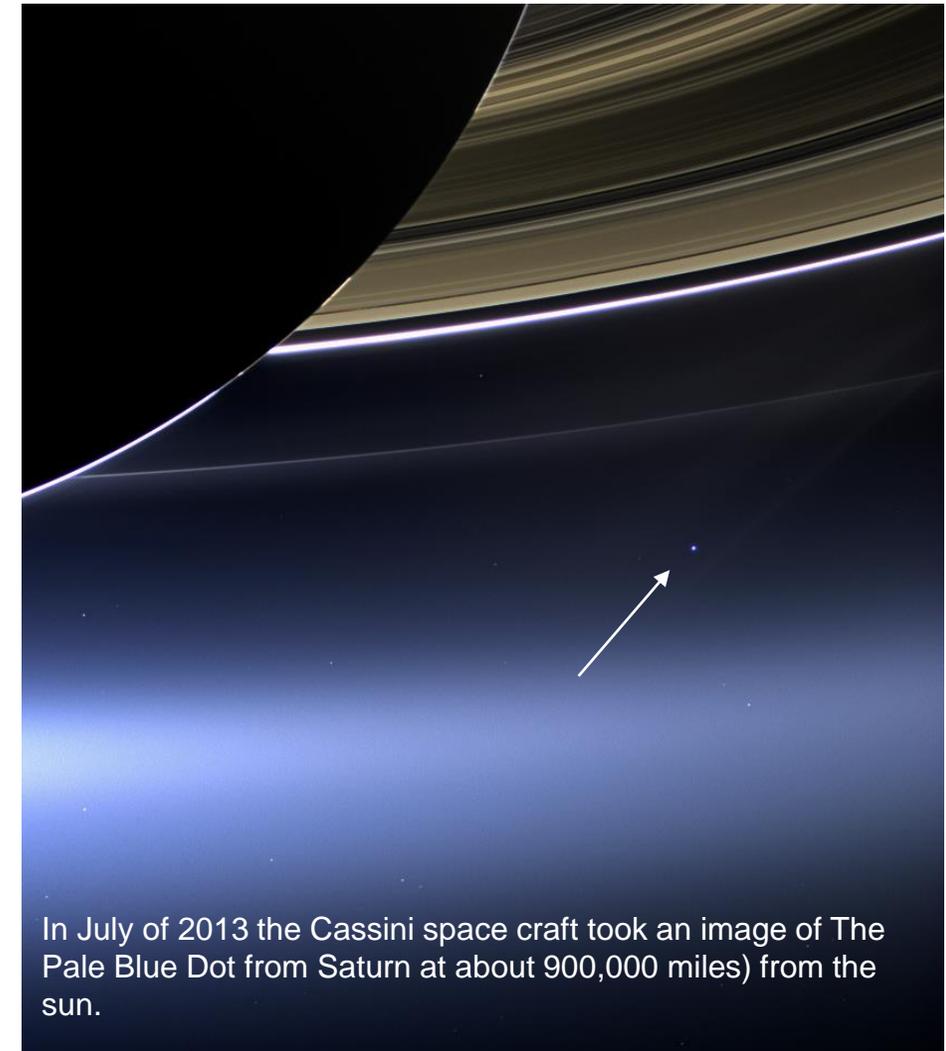
COMET NEOWISE



A Comets orbit around the Sun



Pale Blue Dot is a photograph of planet Earth taken on February 14, 1990, by the *Voyager 1* space probe from a record distance of about 3.7 billion miles.



In July of 2013 the Cassini space craft took an image of The Pale Blue Dot from Saturn (at about 900,000 miles) from the sun.

“That’s here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives ... on a mote of dust suspended in a sunbeam.” -Carl Sagan

THE SOLAR SYSTEM WALK

