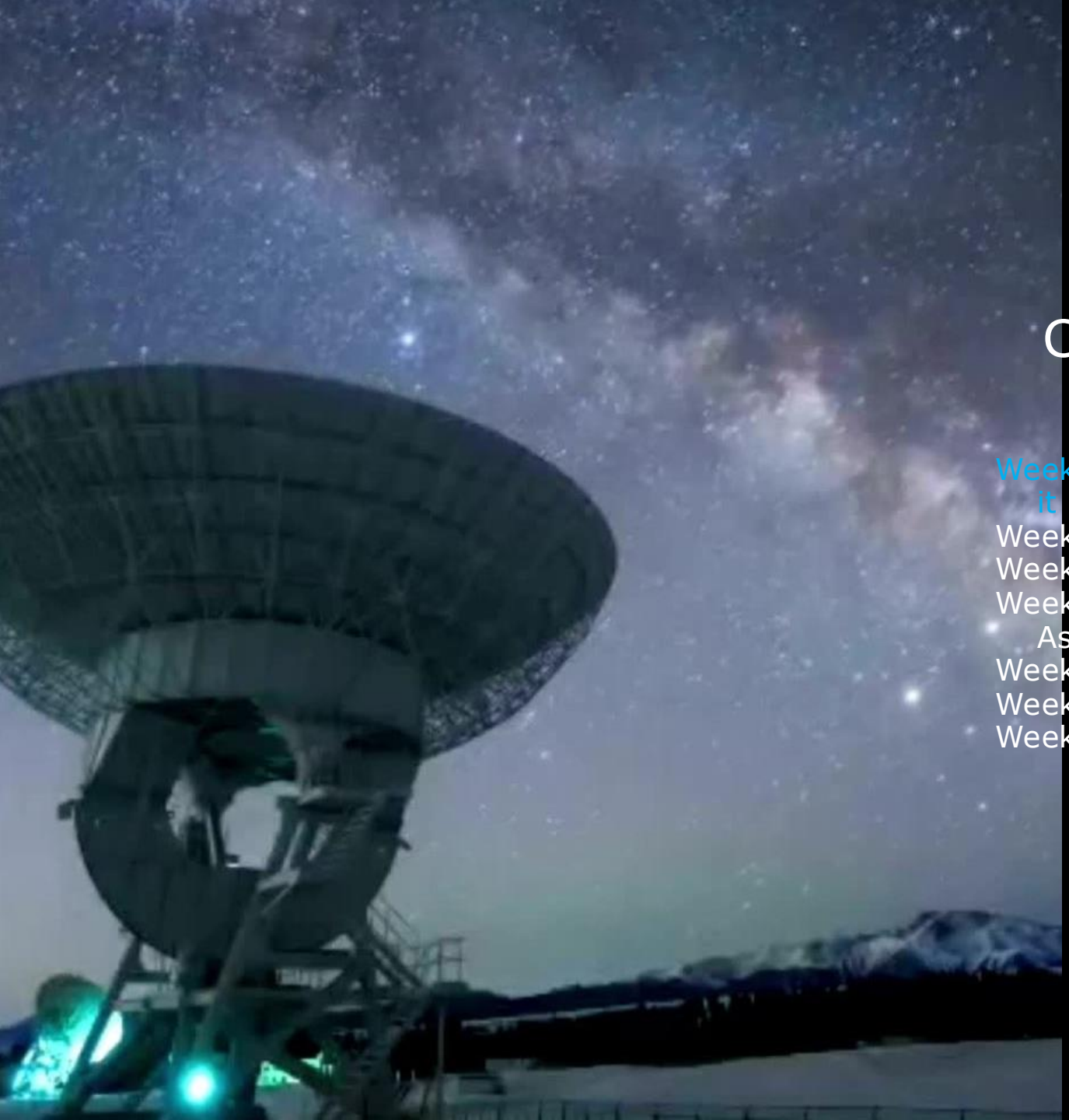
Evening Classes

Week Two

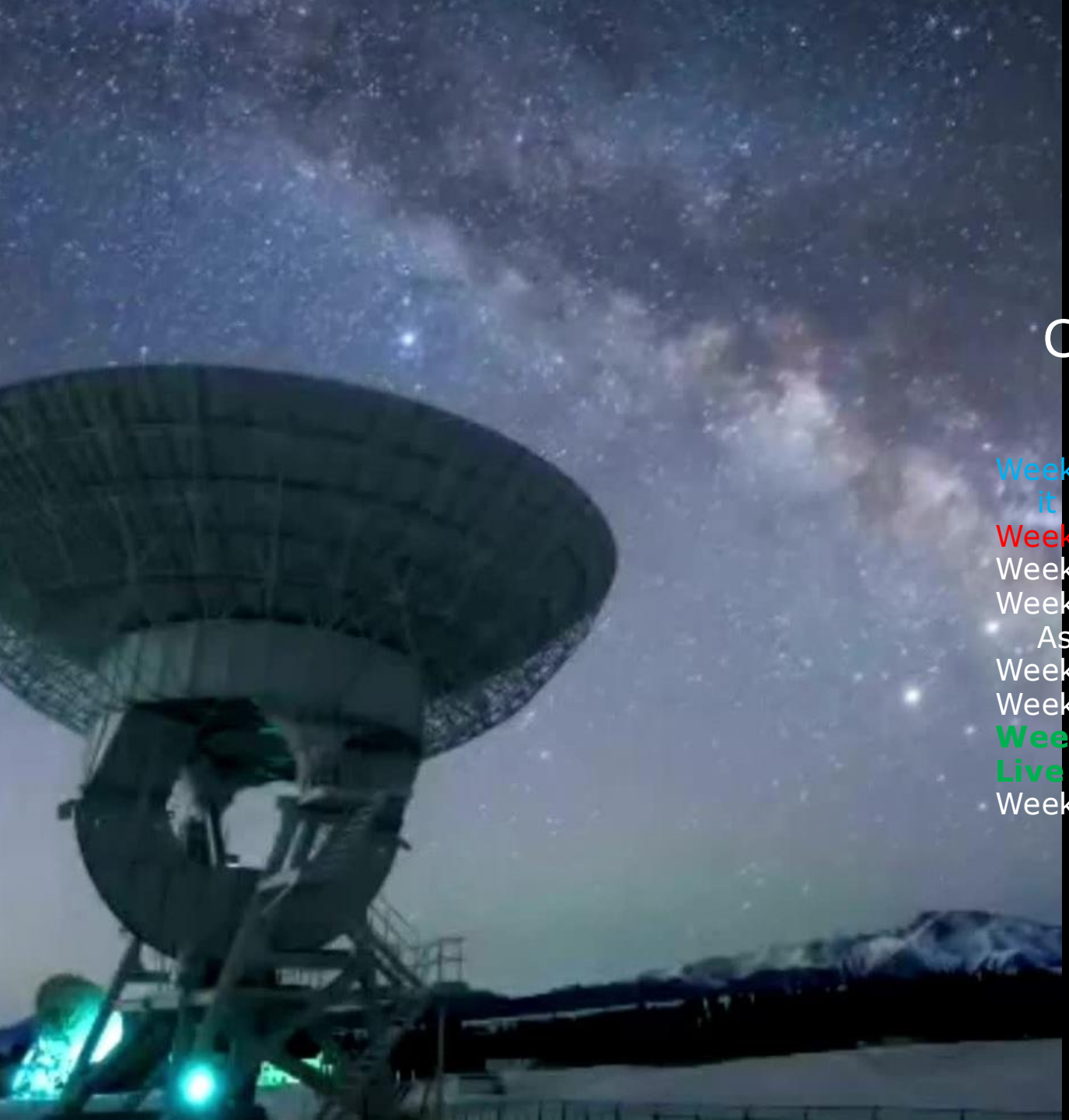
The Planets and Solar System

Presented by John Campbell



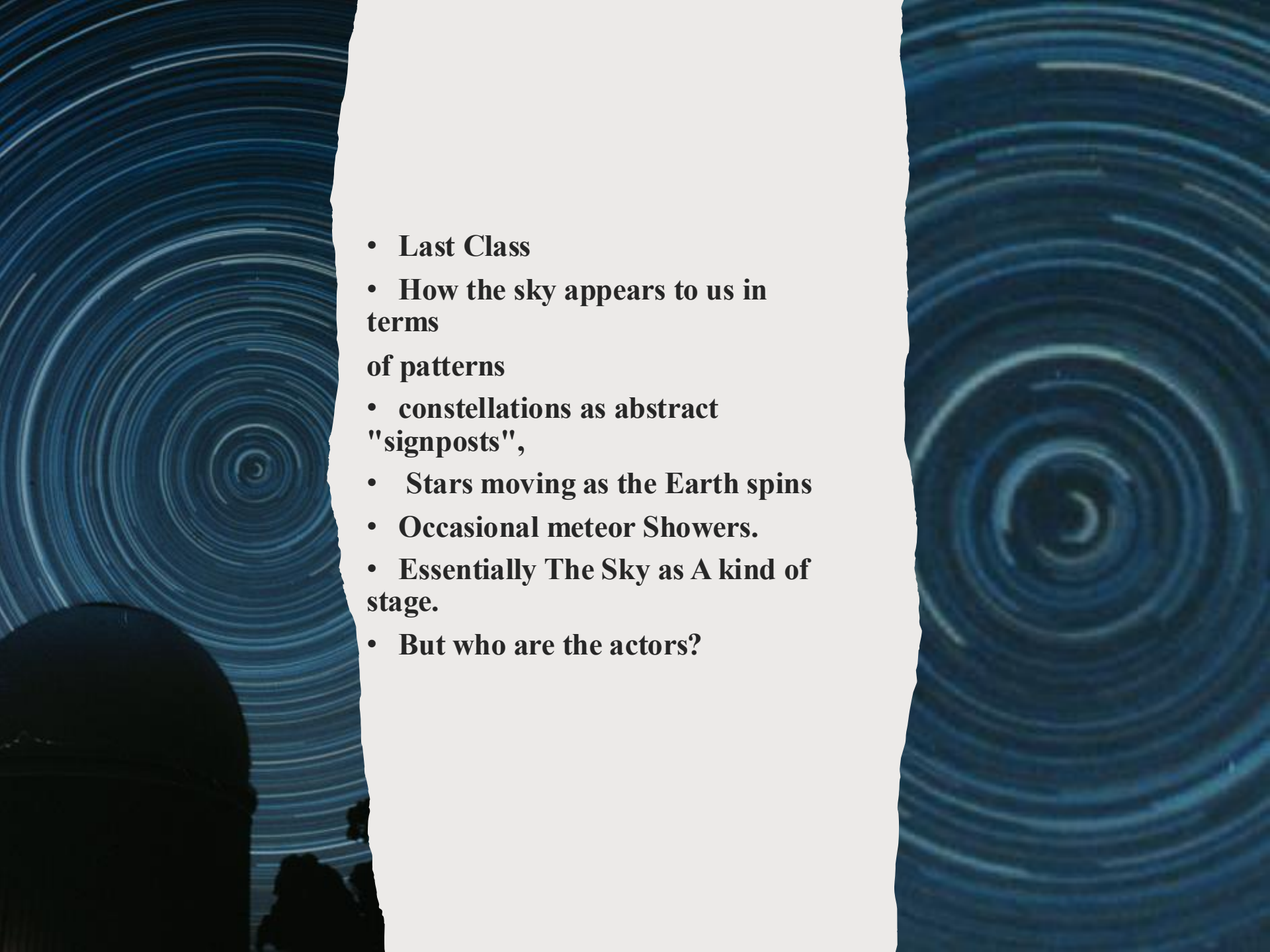
Course Outline

Week 1: The Sky as we see it
Week 2: The Planets
Week 3: The Stars
Week 4: History of Astronomy
Week 5:
Week 6: Week 7: Cosmology
Week 8: Alien Worlds



Course Outline

Week 1: The Sky as we see it
Week 2: The Planets
Week 3: The Stars
Week 4: History of Astronomy
Week 5: Deep Sky Objects
Week 6: Cosmology
Week 7: Telescopes + Live Class on March 16th
Week 8: Alien Worlds



- **Last Class**
- **How the sky appears to us in terms**

of patterns

- **constellations as abstract "signposts",**
- **Stars moving as the Earth spins**
- **Occasional meteor Showers.**
- **Essentially The Sky as A kind of stage.**
- **But who are the actors?**


The planets

‘Planet’ means ‘wanderer’ Which originates from what we see planets do...


Mid September, a "Mars year" (2022)
October 31st

Predicting the Future...Mars will appear to go backwards! We call this Retrograde Motion

October 31st

January 12th(retrograde ends)

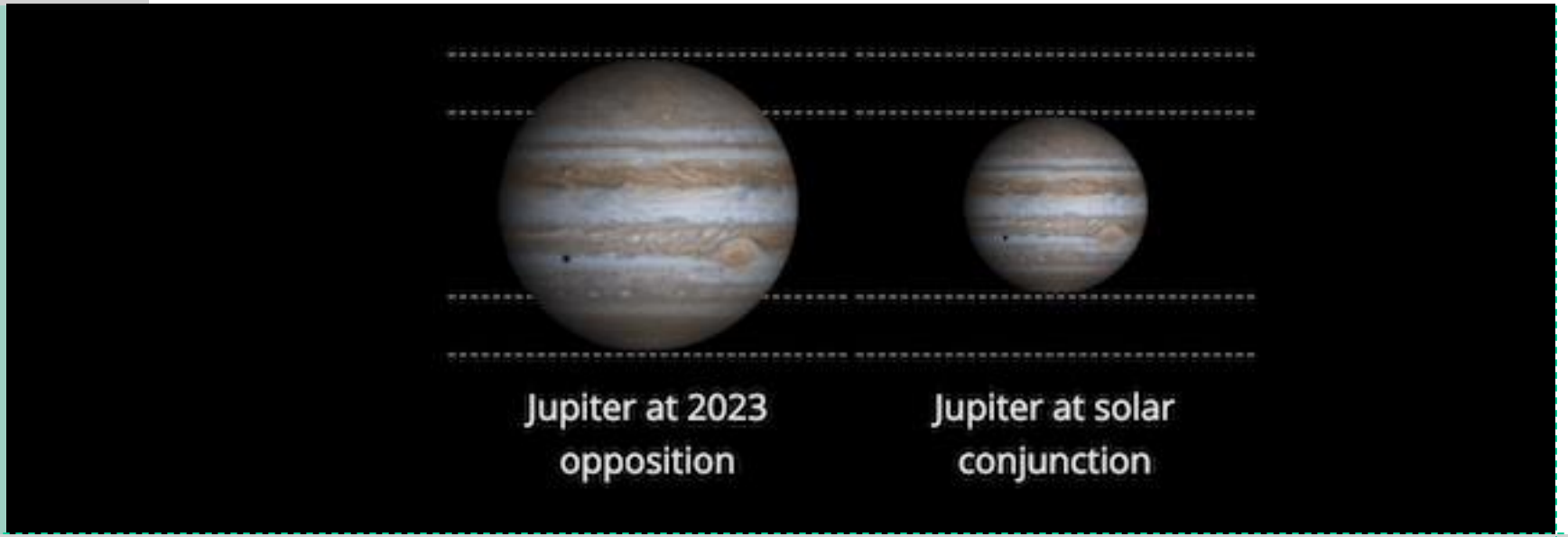

Mars
Taurus

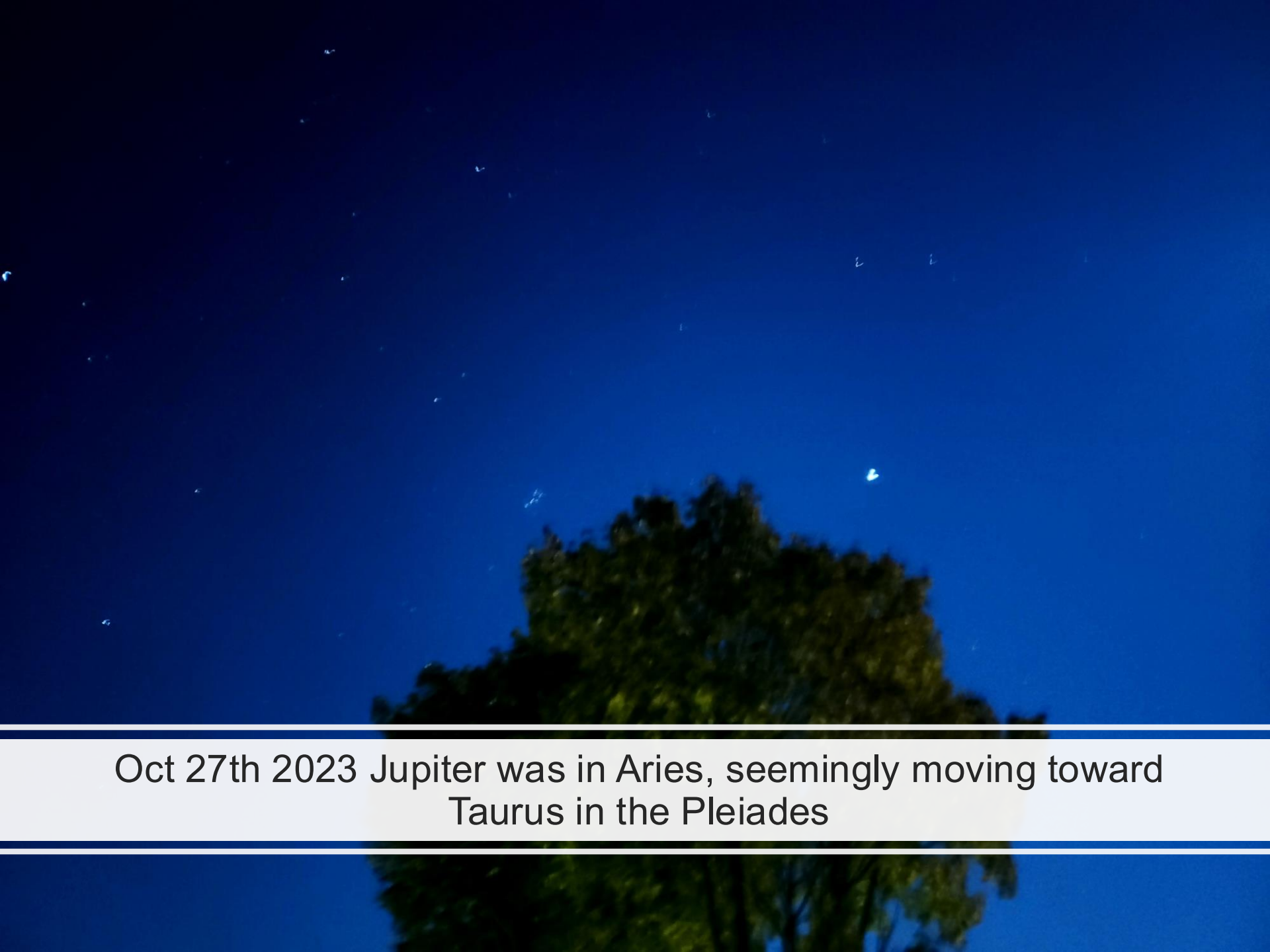
Back to The Present...not a "Mars Year" but Jupiter and Saturn still Bright!

have a look to

the South to South West ,

to that big bright yellow "star" That's Jupiter

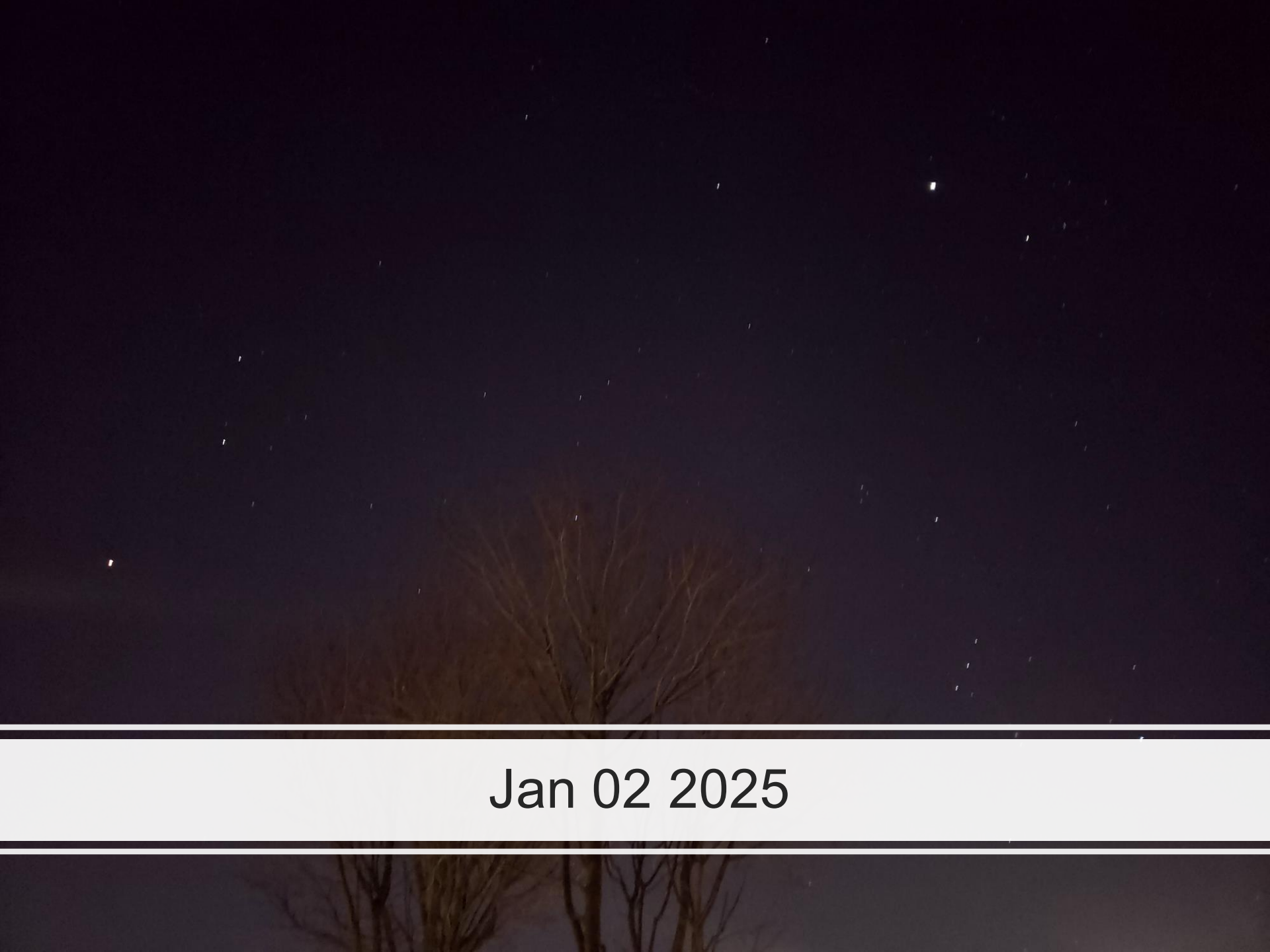




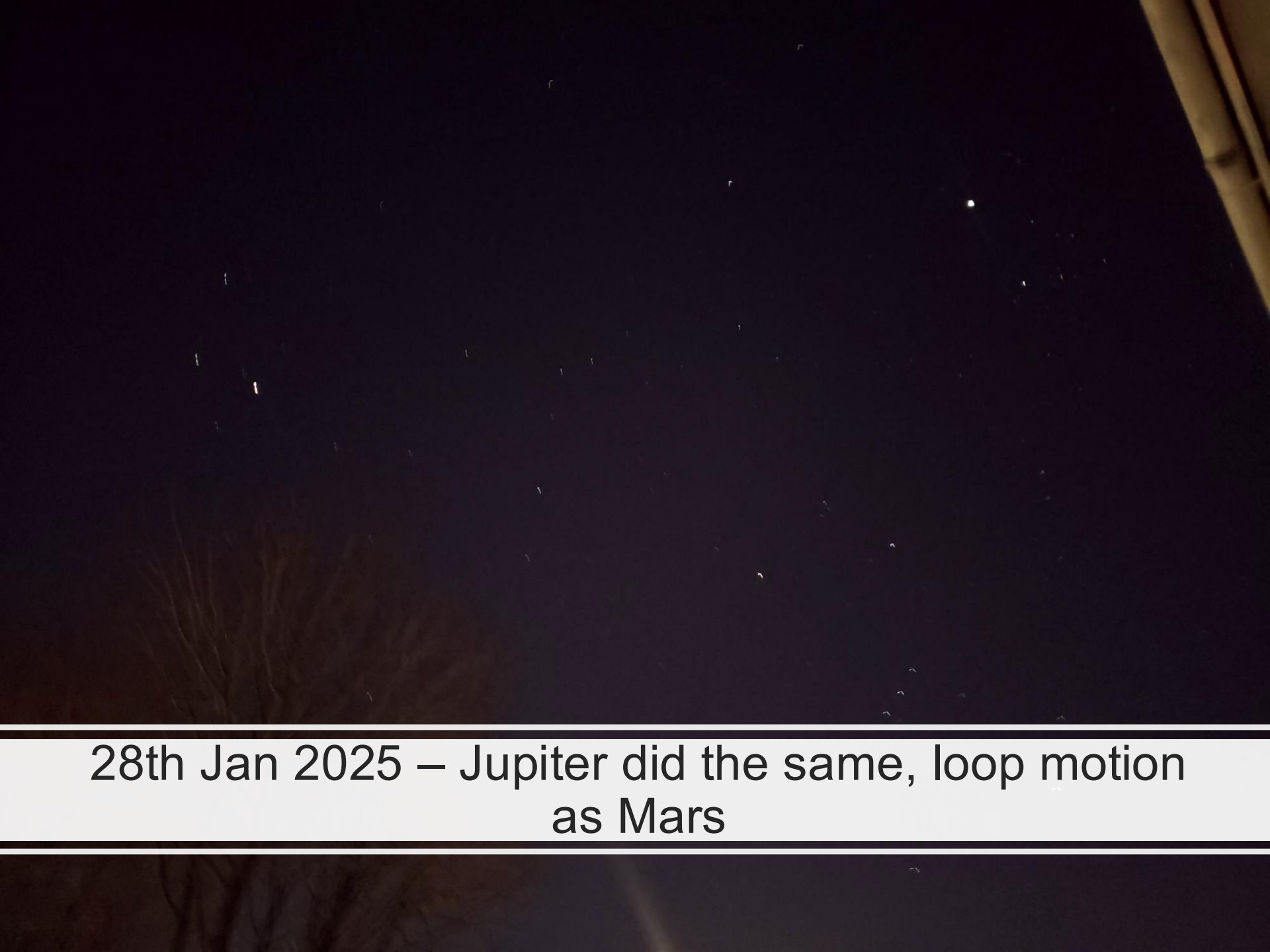
Oct 27th 2023 Jupiter was in Aries, seemingly moving toward Taurus in the Pleiades

Then in Oct 2024 Jupiter was in the constellation Taurus, Mars (less bright) was in Gemini last year

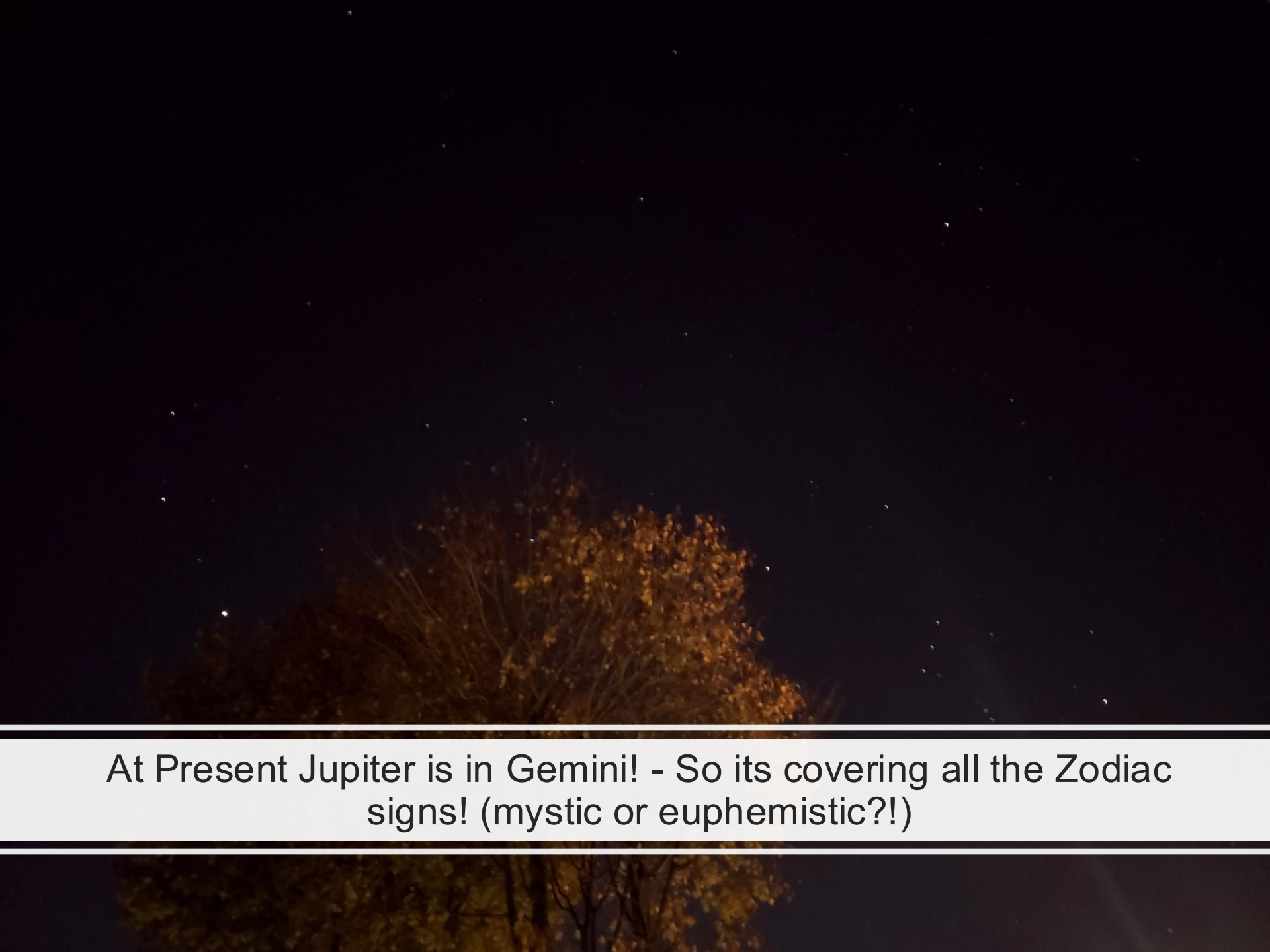
12th December 2024



Jan 02 2025

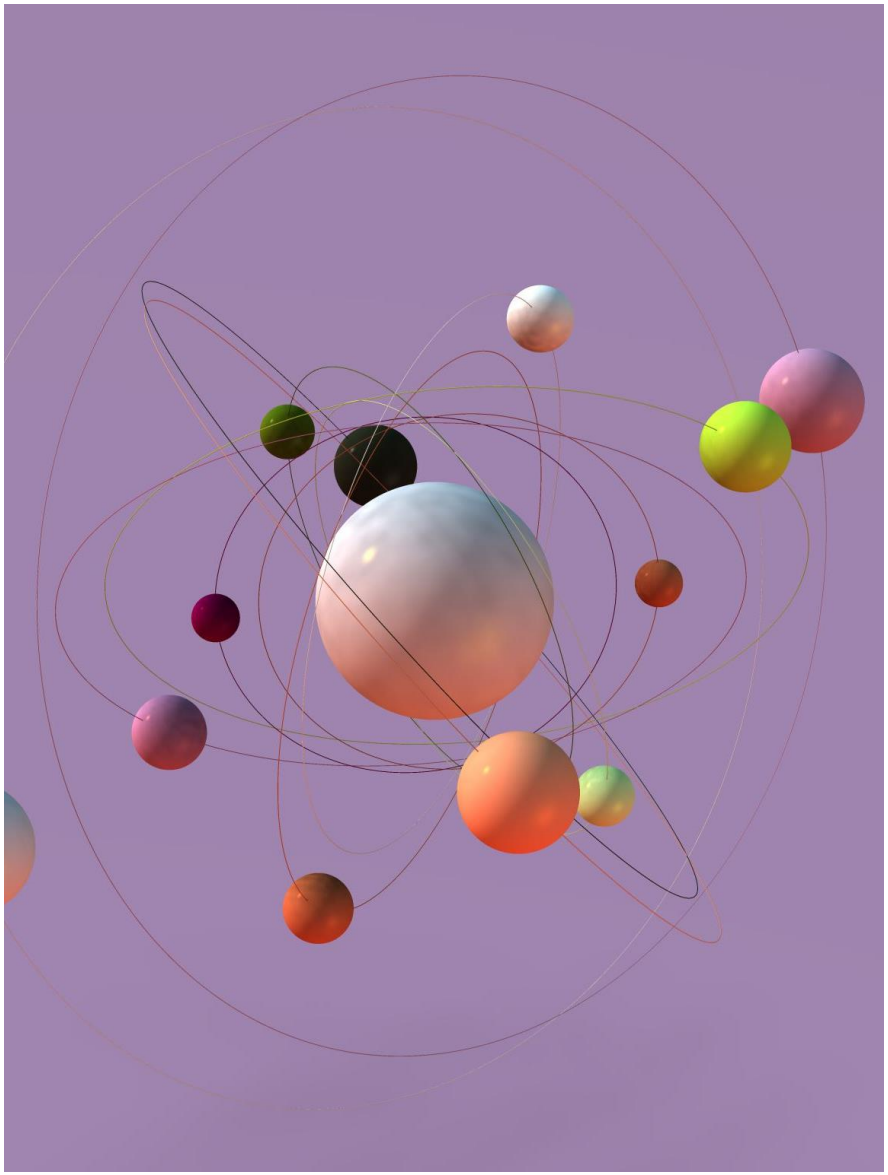


28th Jan 2025 – Jupiter did the same, loop motion as Mars



At Present Jupiter is in Gemini! - So its covering all the Zodiac signs! (mystic or euphemistic?!)

- The same looping motion, seen in mars, jupiter, saturn, gave planets their designation as "wandering" stars
- In between the time when planetary retrograde begins and the time when planetary retrograde ends the planet in question appears at its brightest
- The question of course is Why?



How do Mars and Jupiter Compare in their retrograde?

As they change -

In terms of brightness?

In terms of position?

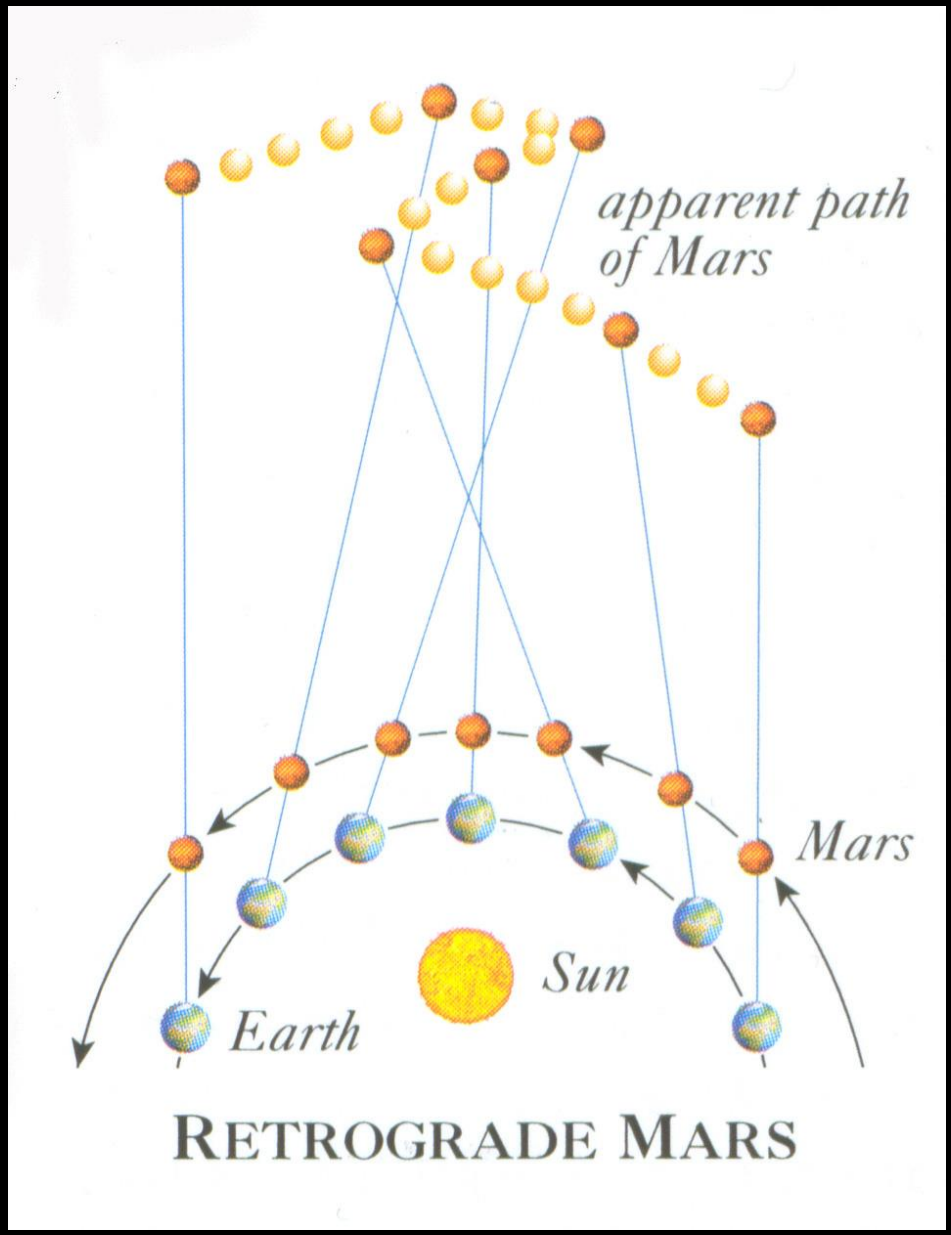
In terms of rate of change?

Reasons Will Be Explained but Useful

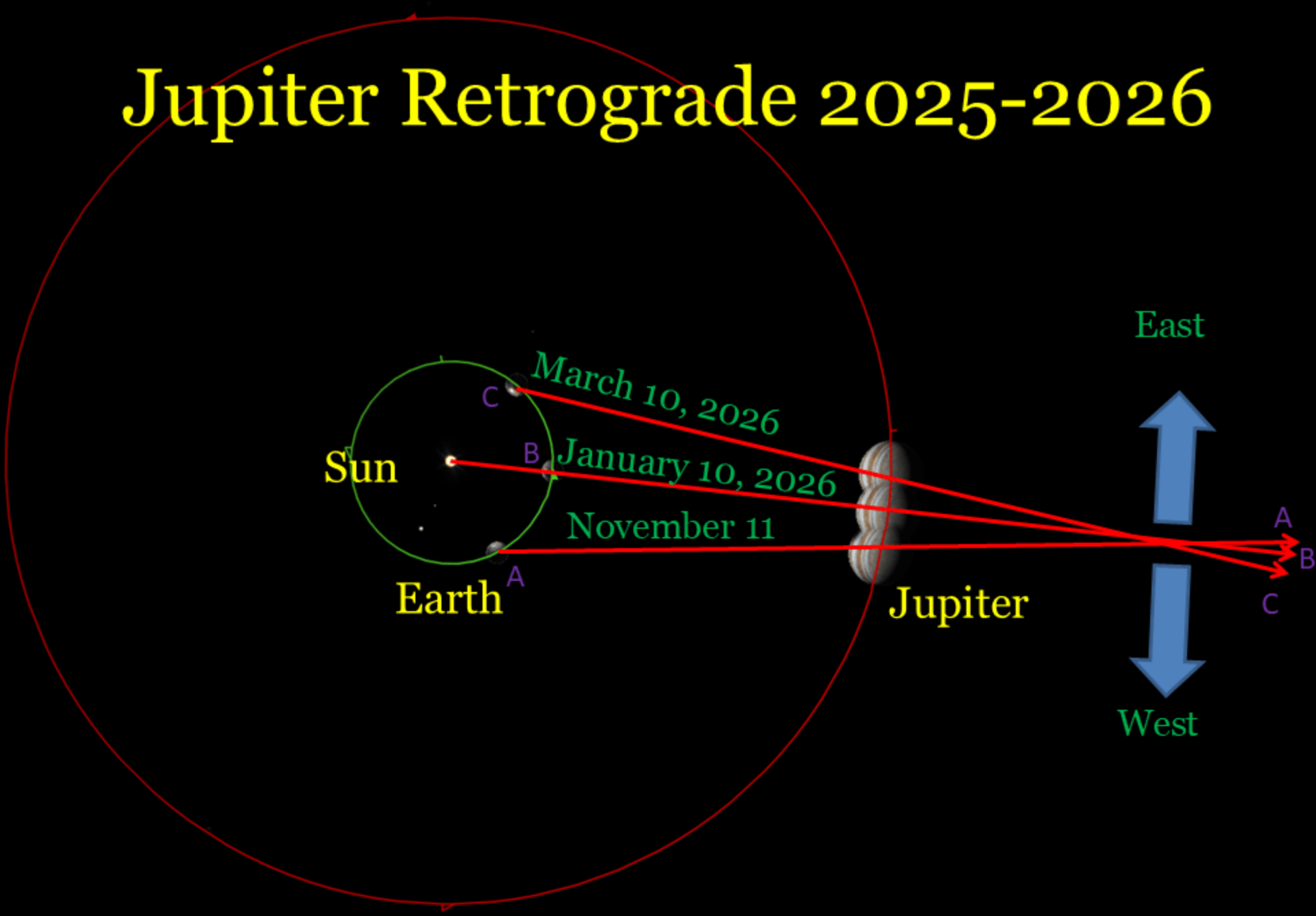
To Think about what we are seeing.

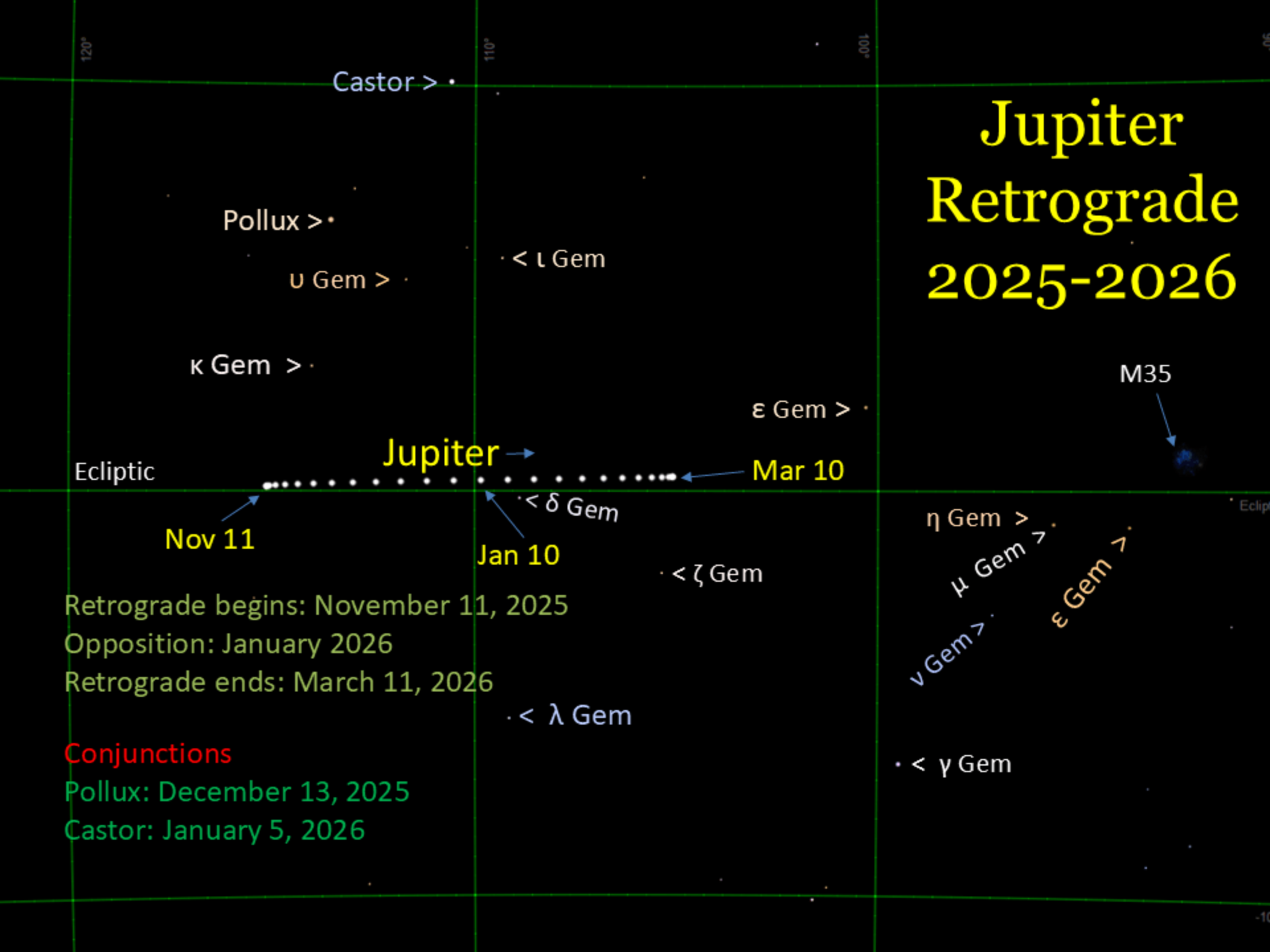
Retrograde Motion

As Earth passes Mars, Mars appears to move from east to west.



Jupiter Retrograde 2025-2026




Jupiter Retrograde 2025-2026
Castor >
Pollux >
ι Gem
υ Gem >
κ Gem >
M35
ε Gem >
Jupiter
Ecliptic
Mar 10
Nov 11
Jan 10
δ Gem
ζ Gem
η Gem >
μ Gem >
ν Gem >
ε Gem >
λ Gem
γ Gem
Retrograde begins: November 11, 2025
Opposition: January 2026
Retrograde ends: March 11, 2026
Conjunctions
Pollux: December 13, 2025
Castor: January 5, 2026

Conditions for Observing Planets

- Where the Planet is relative to Constellations/Moon
- Is the planet at Opposition
- Light pollution

- Small apertures okay

- High magnification (100x – 250x)

- Steady ‘seeing’

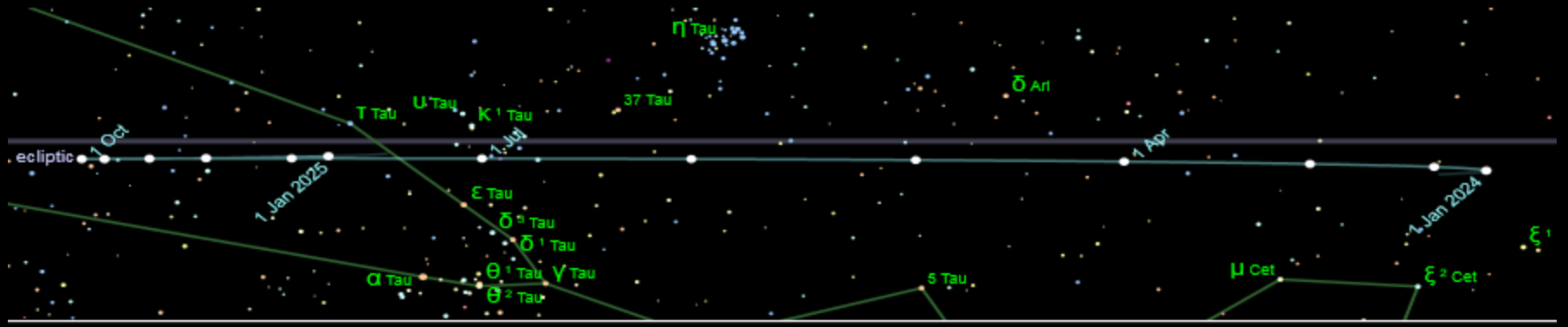
The planet is closest to the earth at the halfway point in the retrograde because the earth has,in its own orbit, "caught up" with the other planet in its own orbit.

In other words at this point (called opposition) the Earth and the Planet in question are at their closest distance.

For Jupiter this will be on January 2026

For Mars this was on December 7th 2022

It was in Opposition again in Jan 2025



Date	1 Jan	1 Feb	1 Mar	1 Apr	1 May	1 Jun	1 Jul	1 Aug	1 Sep	1 Oct	1 Nov	1 Dec
Magnitude	-2.6	-2.4	-2.2	-2.1	-2.0	-2.0	-2.0	-2.1	-2.3	-2.5	-2.7	-2.8
Diameter	44.0"	39.6"	36.4"	34.1"	32.9"	32.7"	33.6"	35.5"	38.5"	42.2"	46.1"	48.1"
Distance (au)	4.48	4.97	5.41	5.78	5.99	6.02	5.87	5.55	5.12	4.67	4.28	4.09

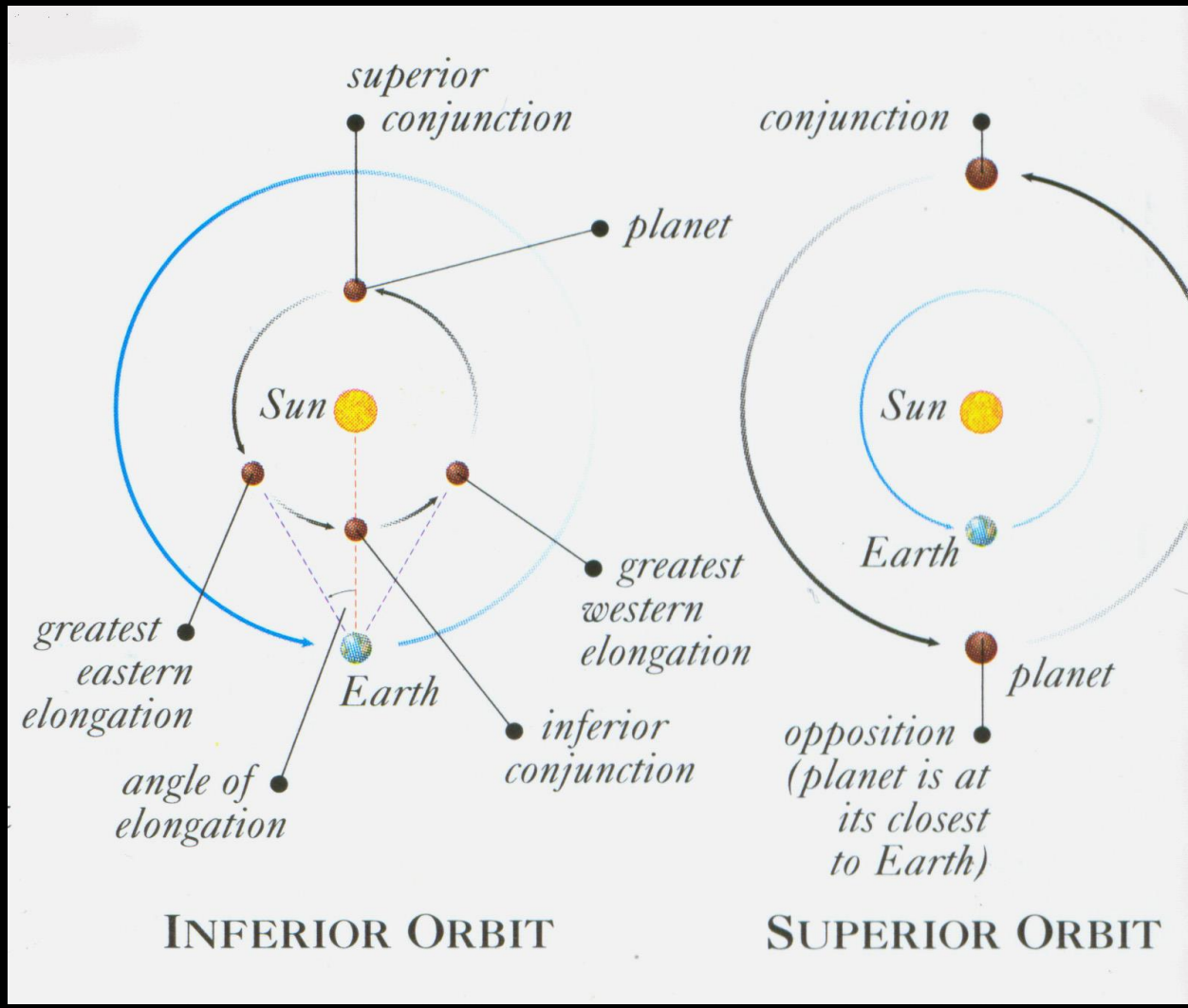
Jupiter through a telescope – very bright and features only detectable at high contrast through a smartphone camera (the human eye is actually much better at imaging bright and dim objects simultaneously)

Jupiter's yearly retrograde is much more dependable than Mars'. Both orbit in the same plane of the solar system as Earth but Mars is more eccentric. This was noticed even in ancient times.

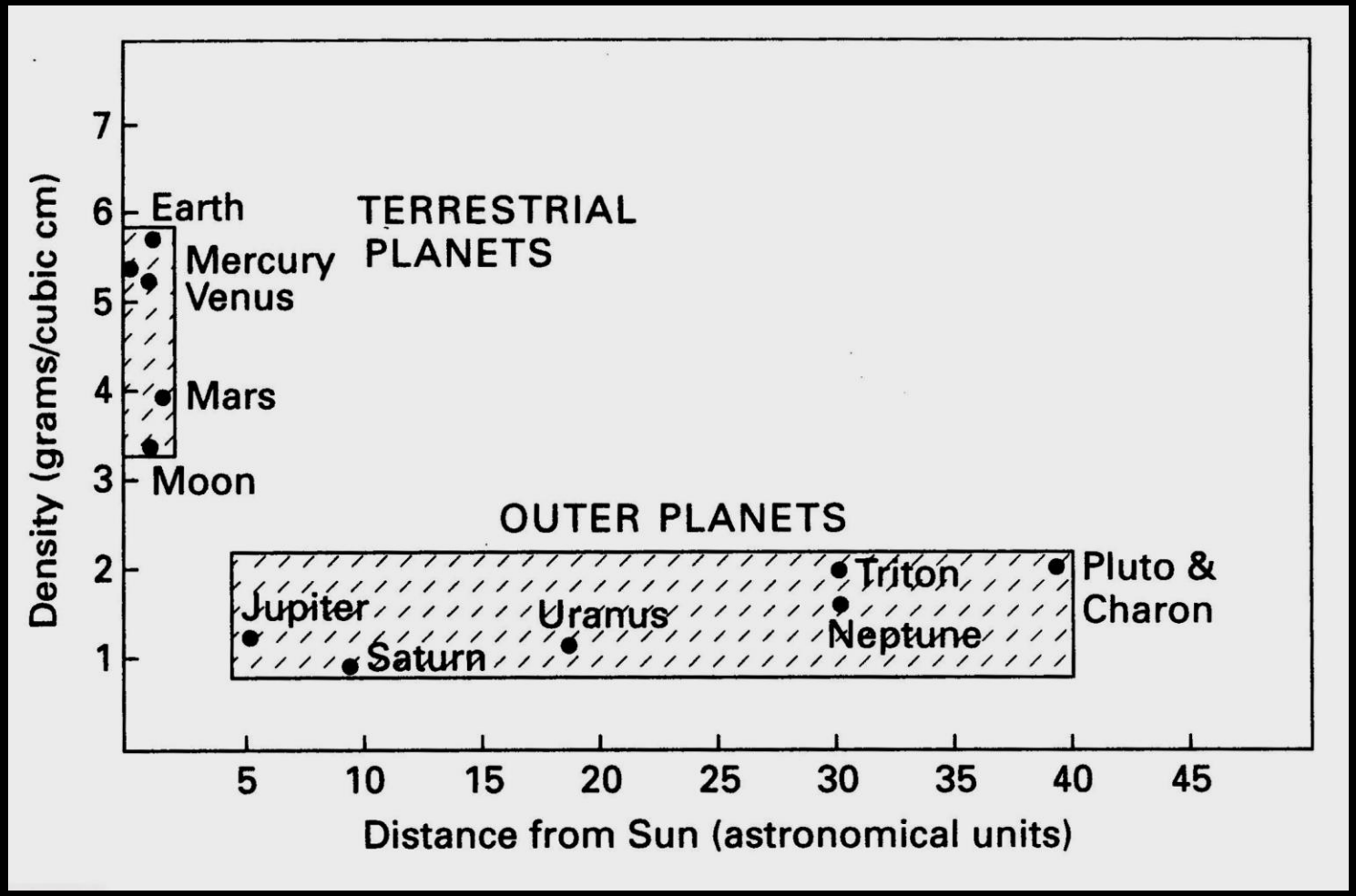
Planetary Alignments

Jupiter, Mars, Saturn are all Superior in their Orbit and so oppositions occur when Earth begins to overtake them in their orbital "laneways"

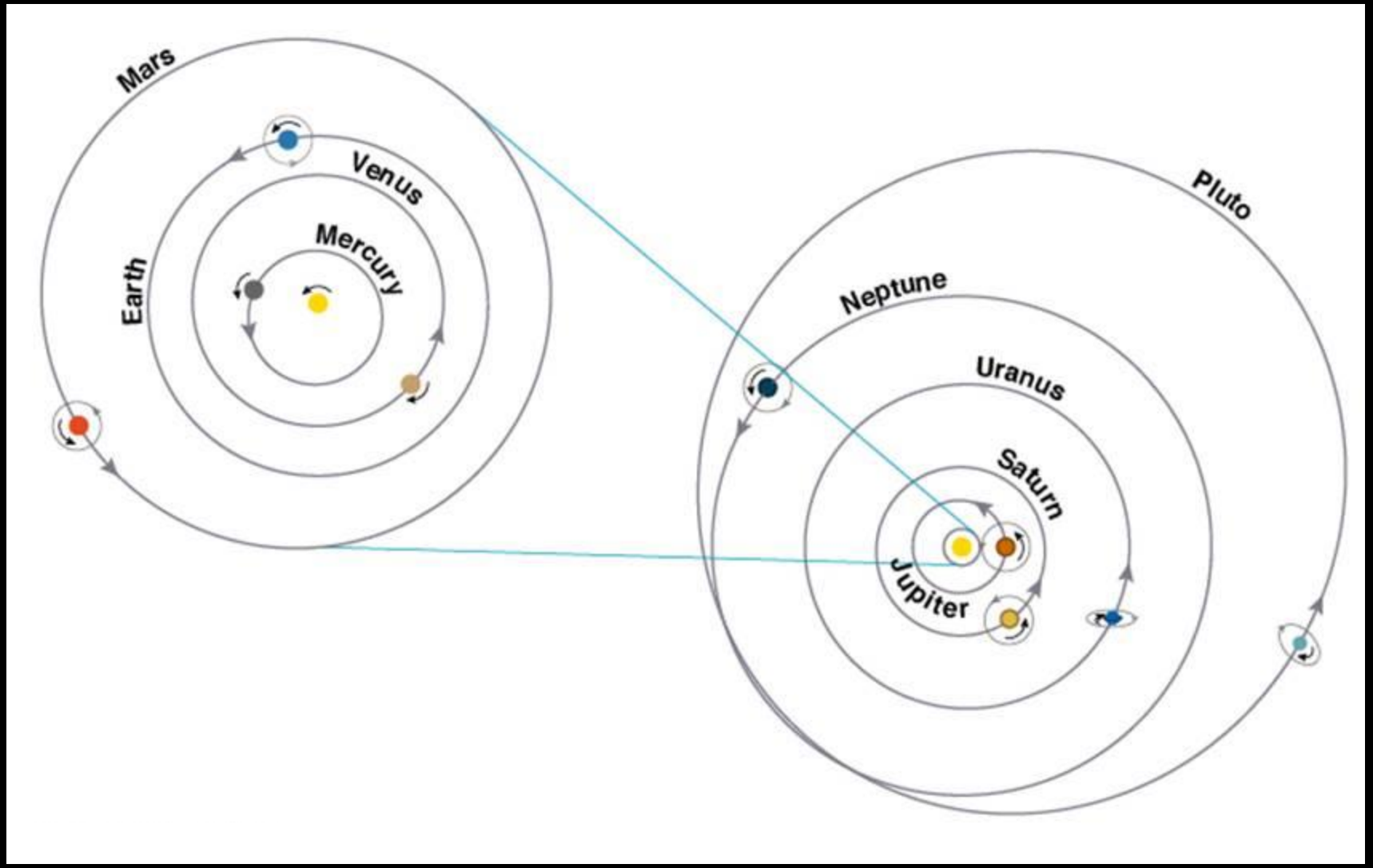
Its sort of vice-versa for the planets with inferior orbits
They are closest at the inferior conjunctions – quid pro quo is that the sun glares them out then!



Planets are a varied lot

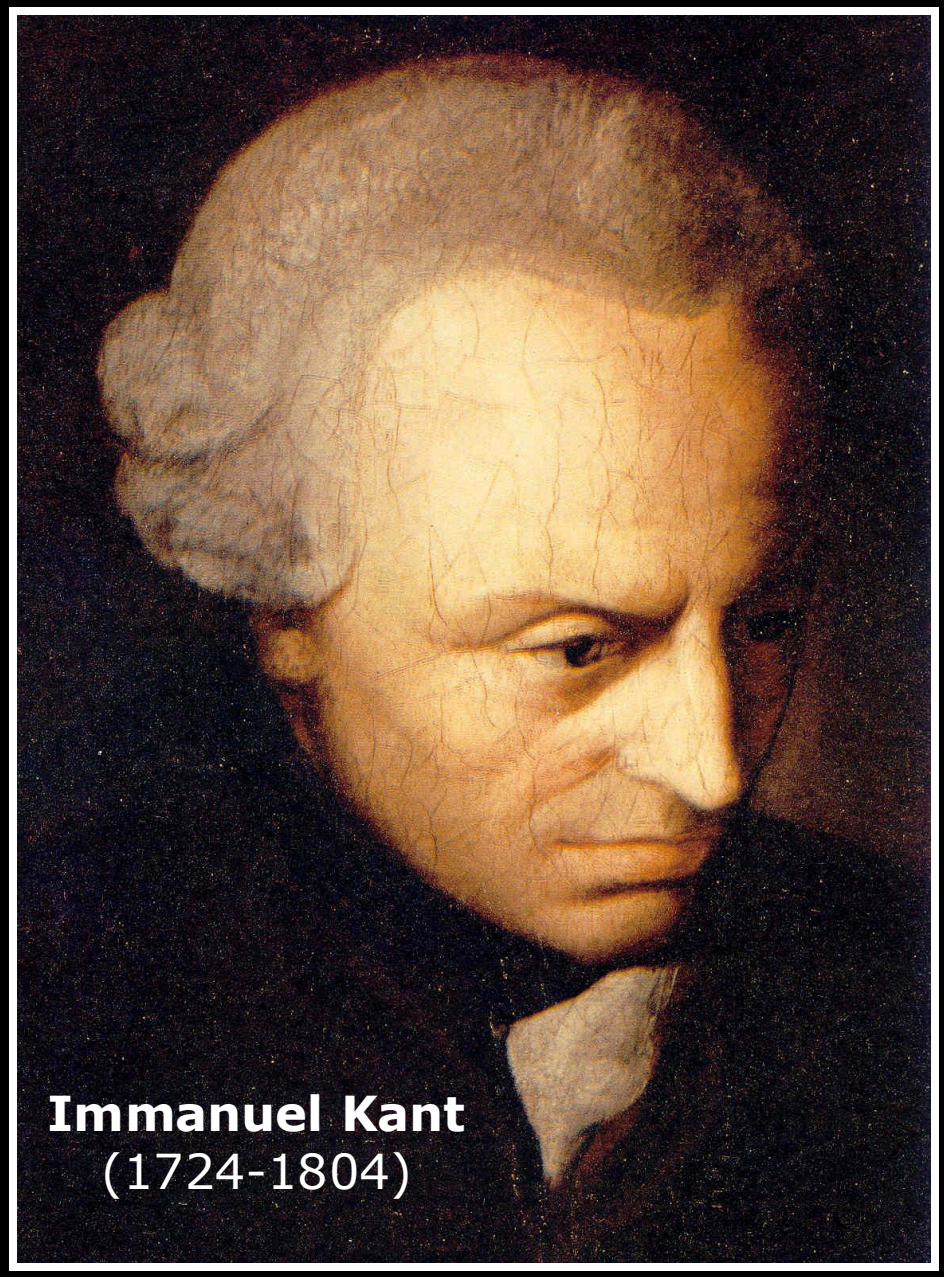


The Inner Solar System

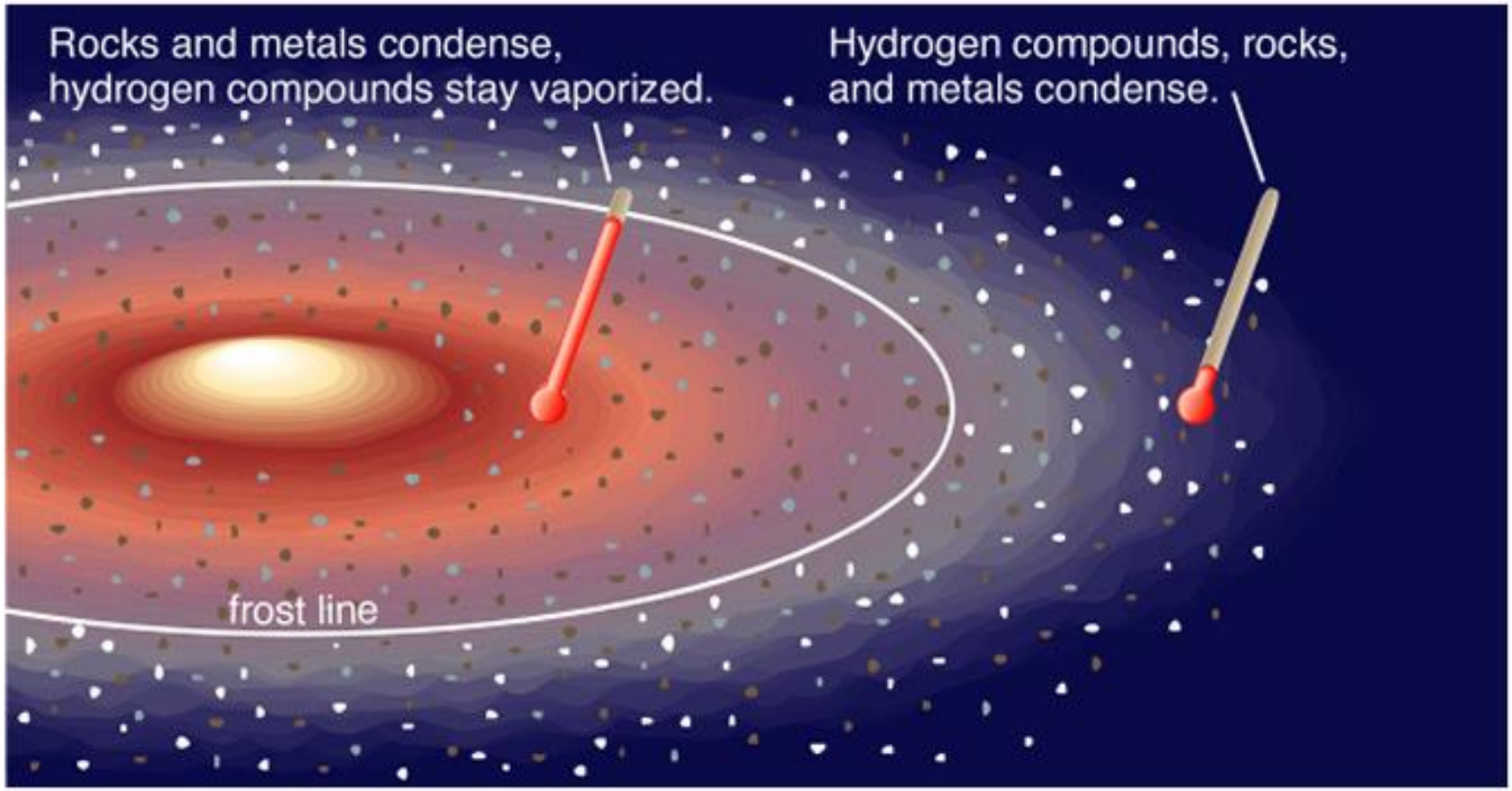


The Nebular Hypothesis

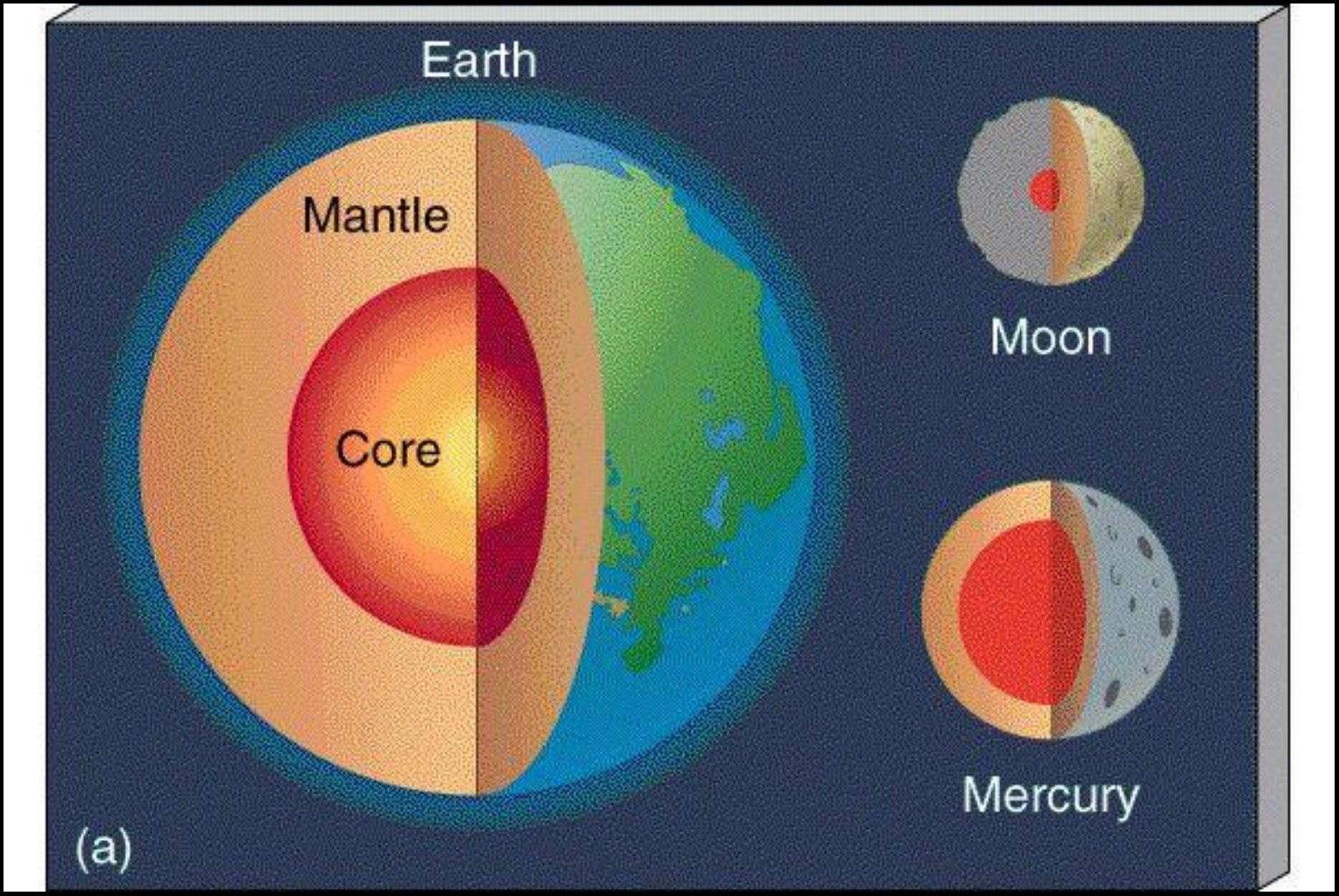
"The Sun & planets formed together from the gravitational collapse of a nebula"



Why planetary compositions differ



The interiors of the terrestrial planets



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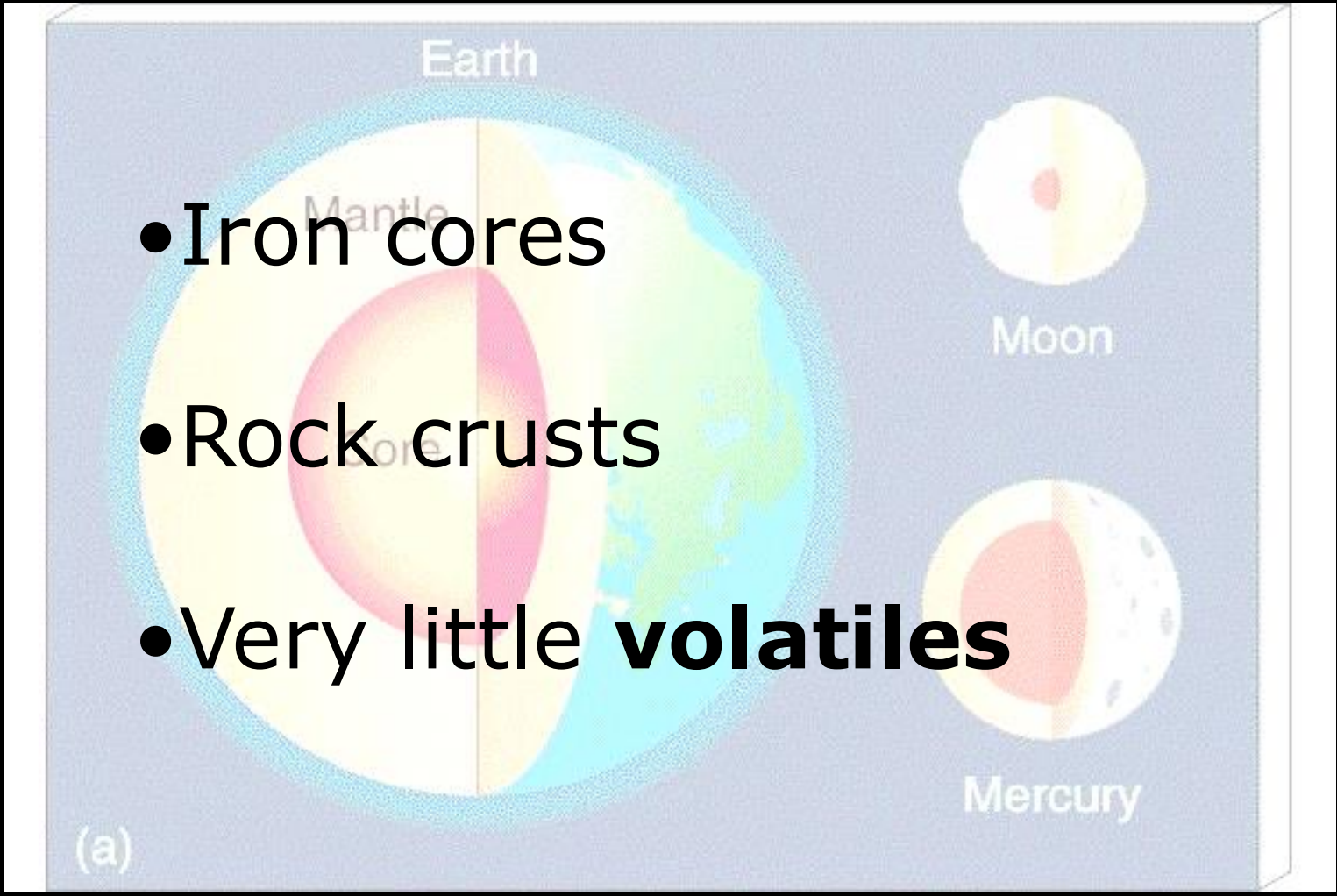
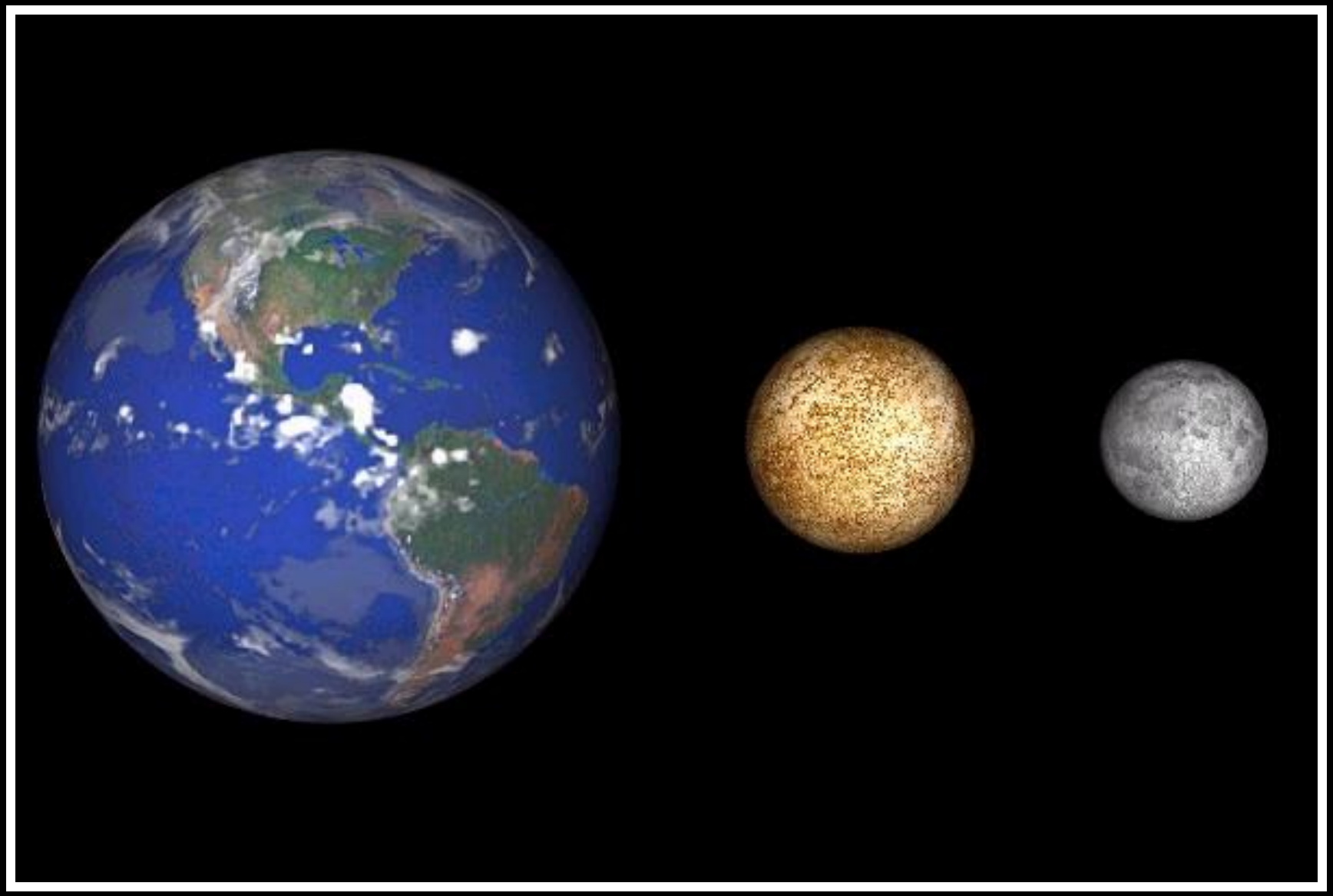


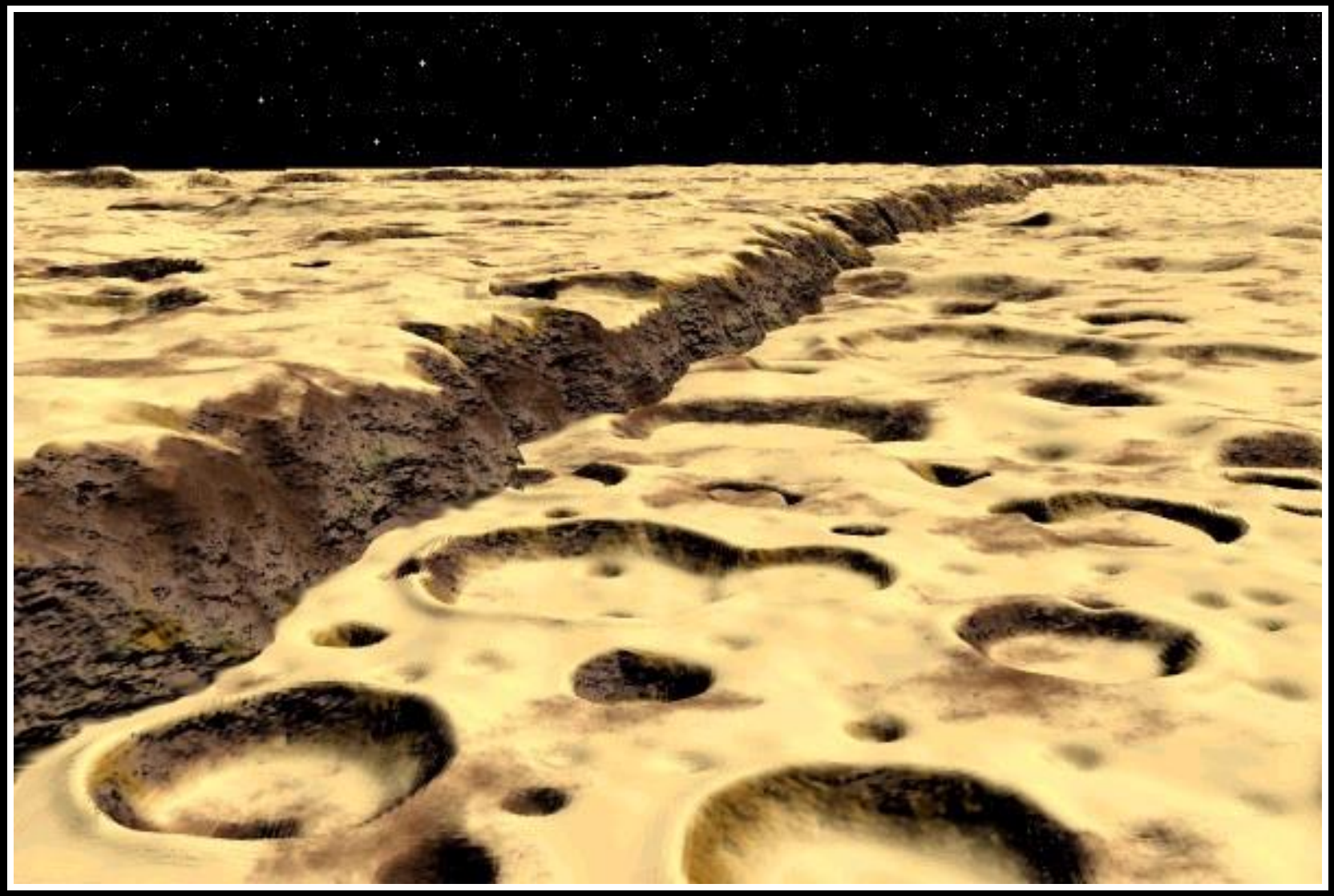
- Iron cores
- Rock crusts
- Very little **volatiles**

Mercury

Earth, Mercury & Moon size comparison



Mercury's faulted landscape



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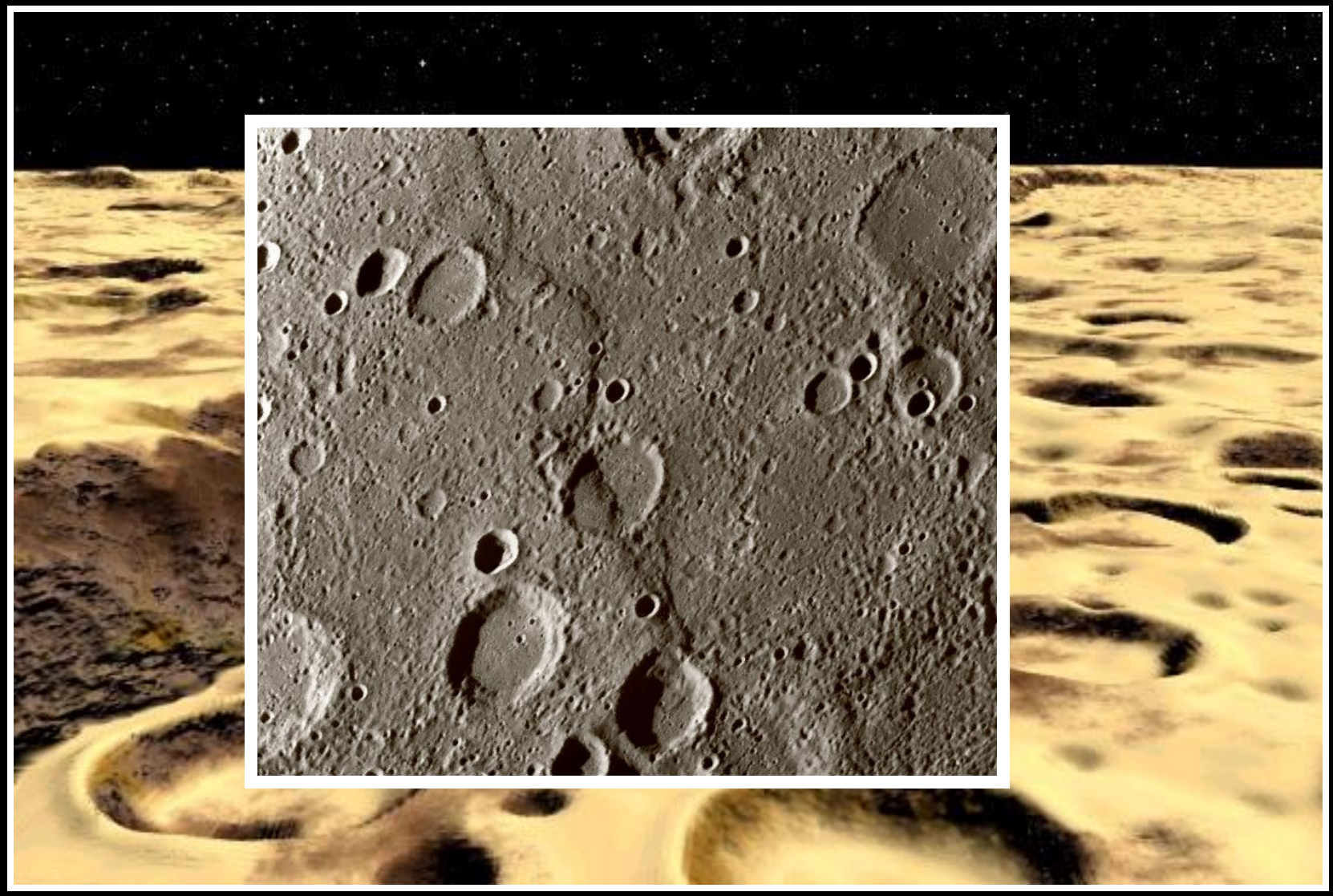
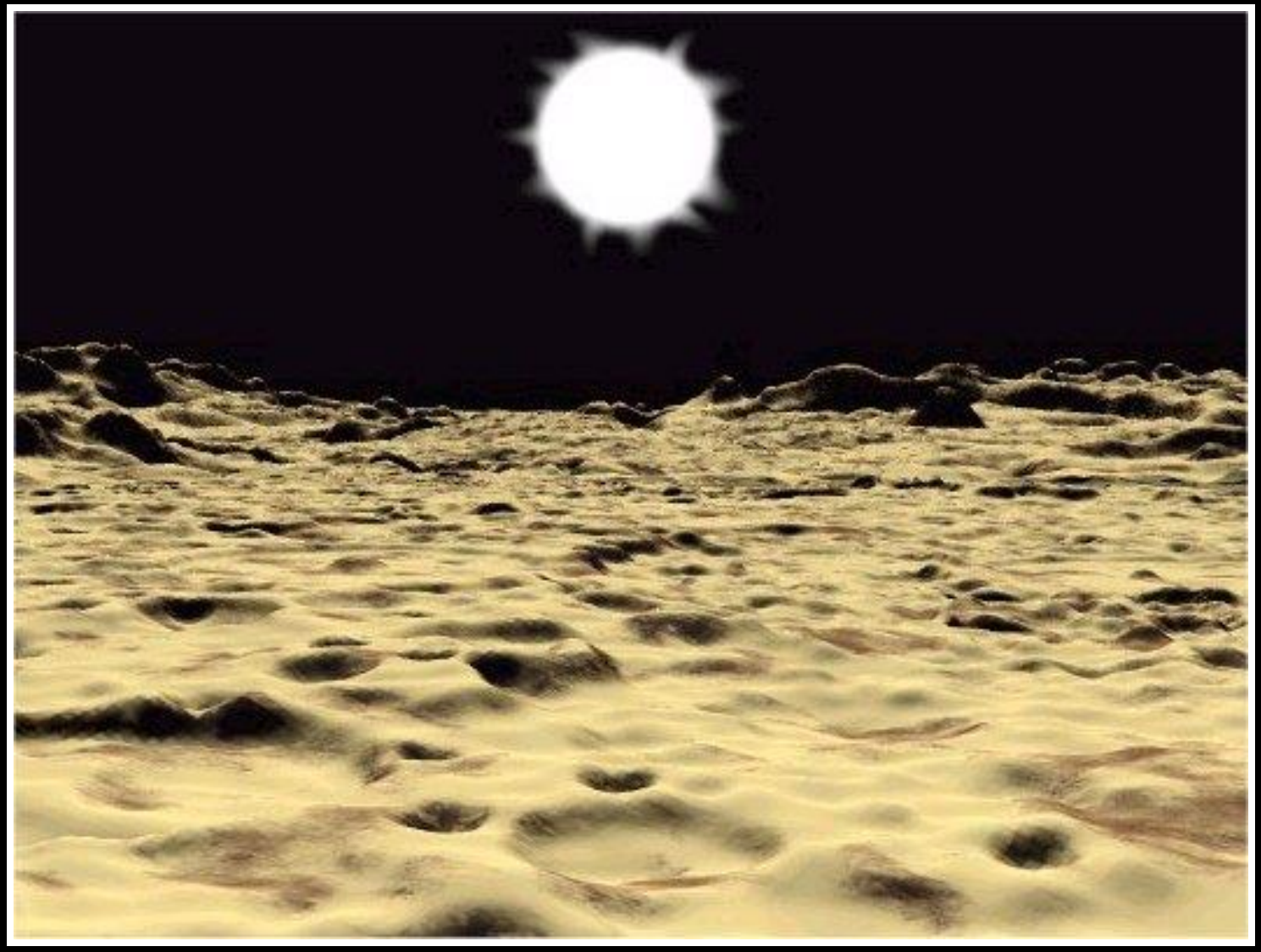
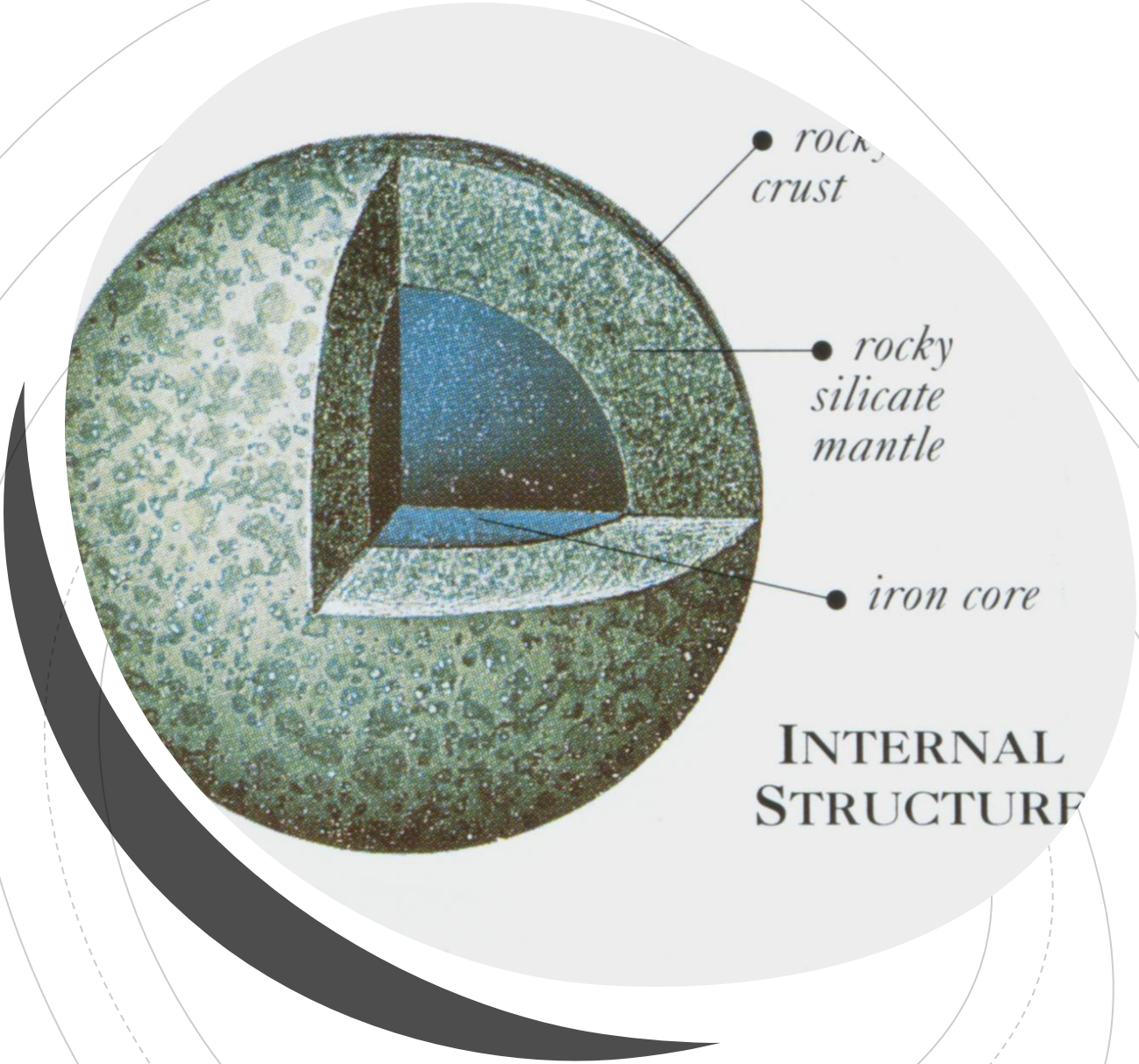
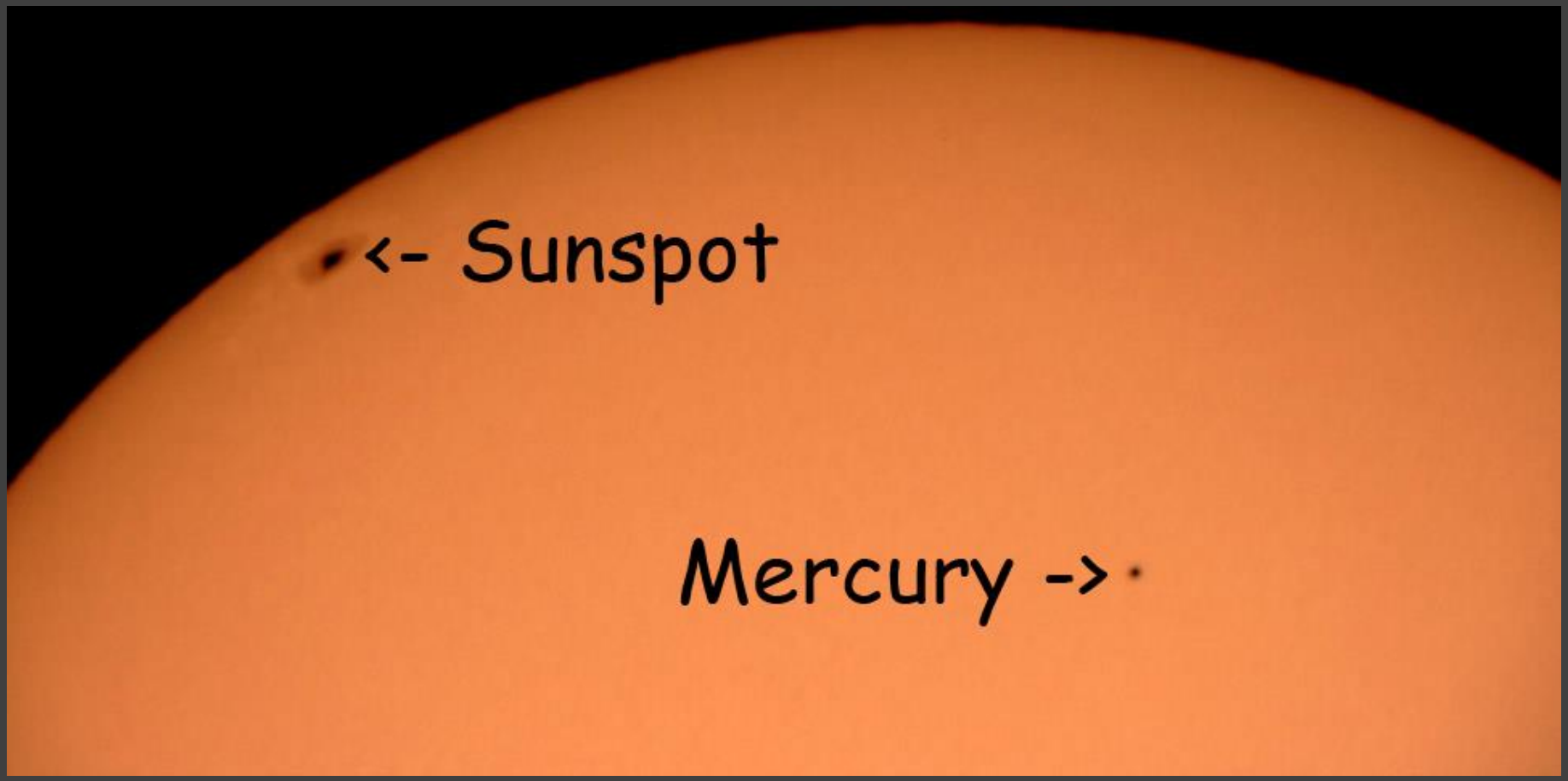


The Sun is 7 times as large in the sky





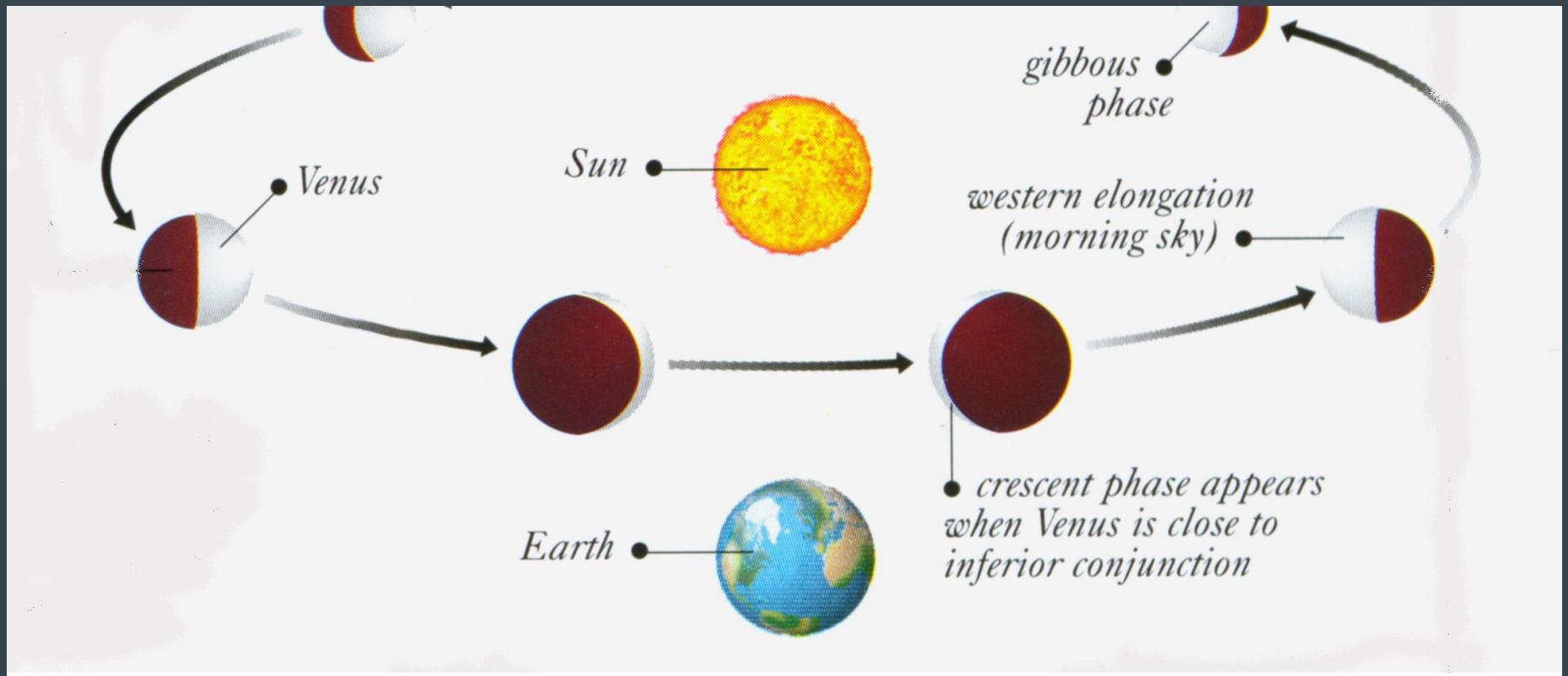
Mercury's Interior - iron ball dipped in mud



- Mercury, like Venus, is closer to the Sun than Earth. So on Earth we can occasionally see Transits of Mercury across the Sun

- Mercury is so close to the Sun that it has a tail!
- Made of sodium ions
- Possible to image using specialised cameras and filters (589nm)
- Forms a component of the solar wind (cosmic rays)

Earth & Venus – size comparison
Most similar planets in size.

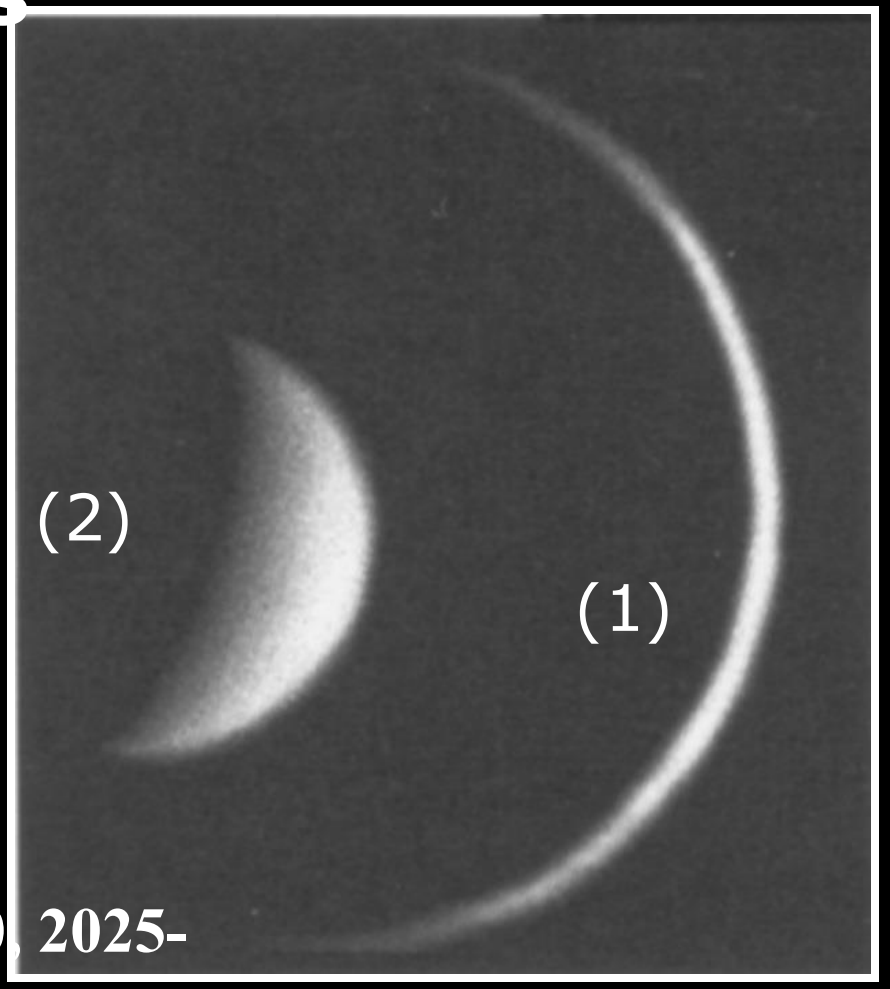


The phases of Venus

Appearance of Venus

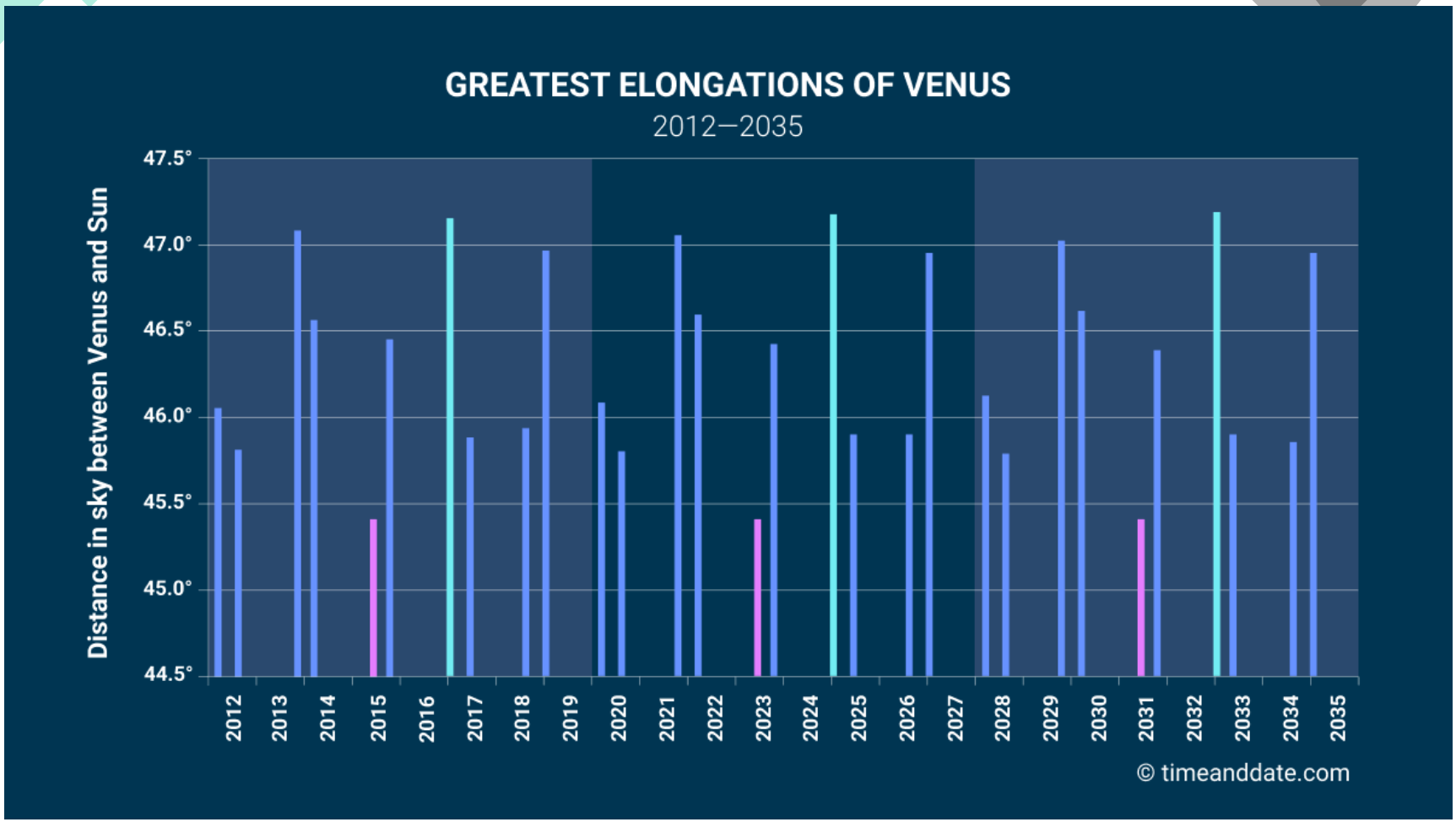
(1)Inferior conjunction
Venus at brightest
(which is ironically at its
Sharpest crescent) always
Follows its greatest elongation

(2)Greatest western
Elongation -



Venus is at greatest elongation – farthest from the sunset – on **Jan 10, 2025- following that it will approach inferior conjunction and technically visible while the sun is still out!**

As Venus gets closer to Earth, it grows in apparent size but becomes a crescent.


GREATEST ELONGATIONS OF VENUS
2012—2035
Distance in sky between Venus and Sun
47.5°
47.0°
46.5°
46.0°
45.5°
45.0°
44.5°
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
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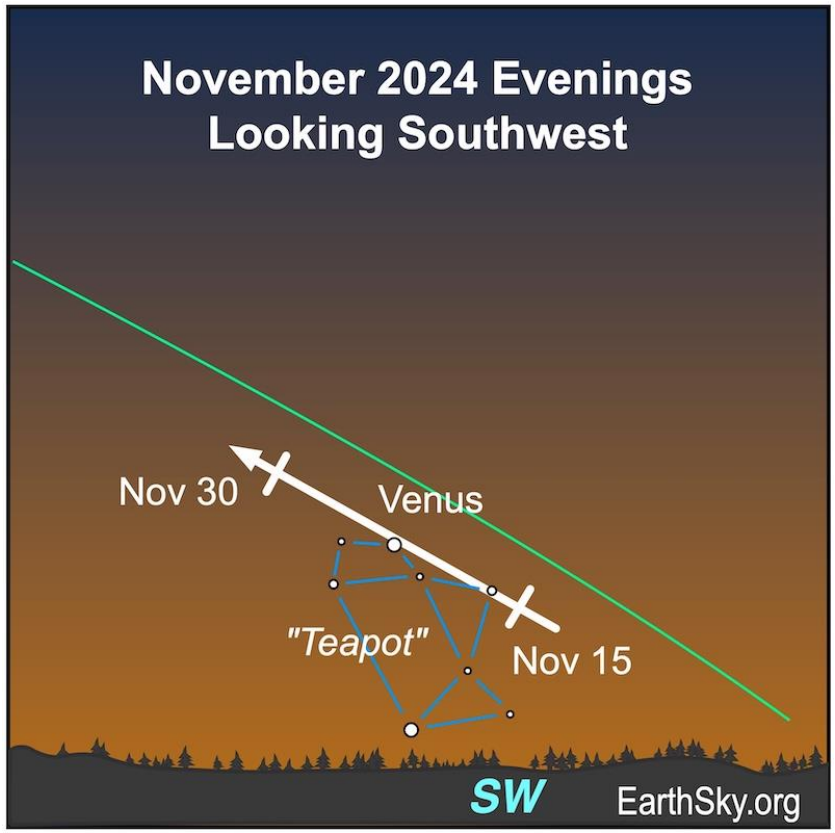
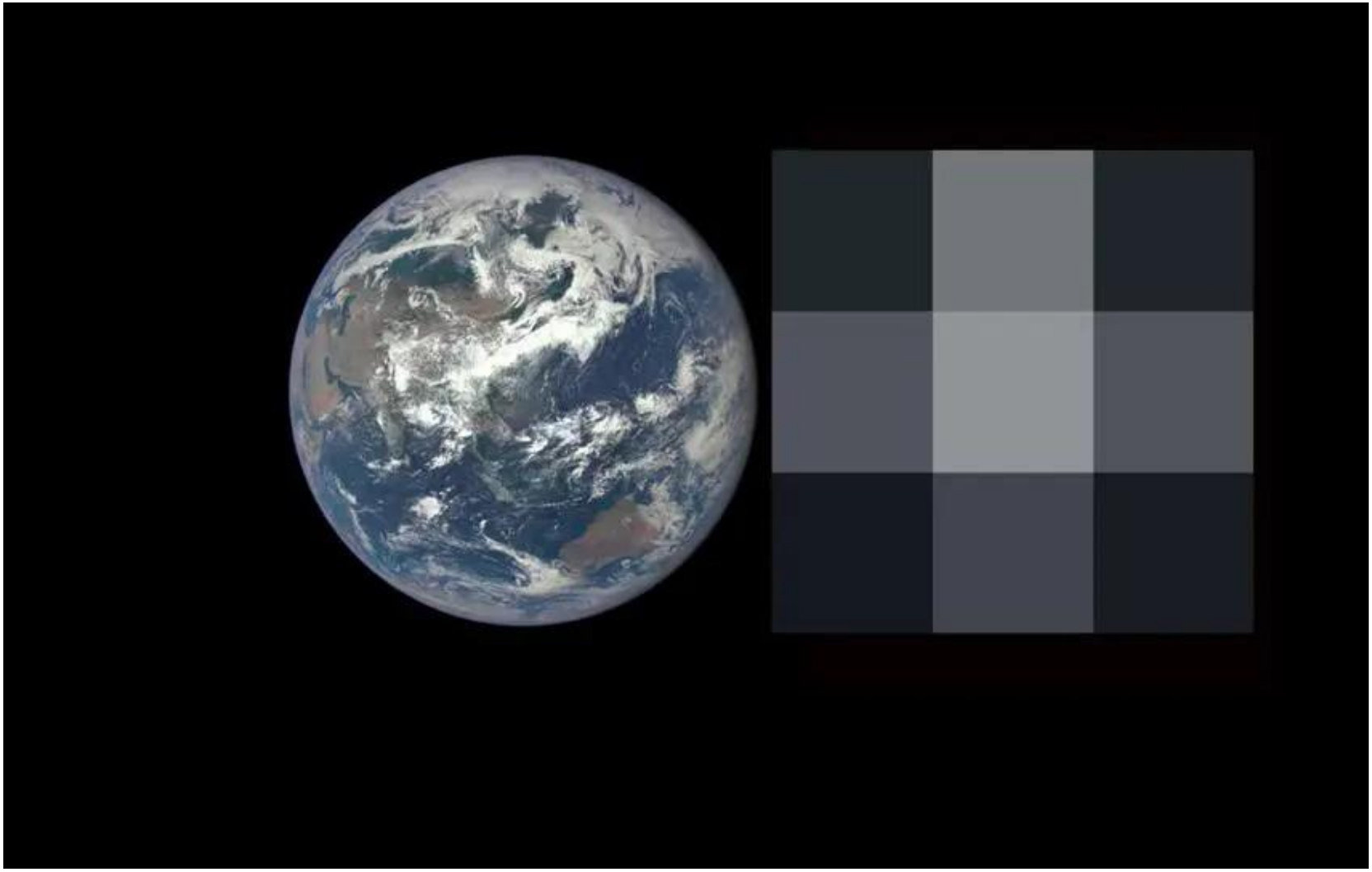
November 2024 Evenings
Looking Southwest
Nov 5
Venus
Nov 4
Mercury
Nov 3
EarthSky.org
SW

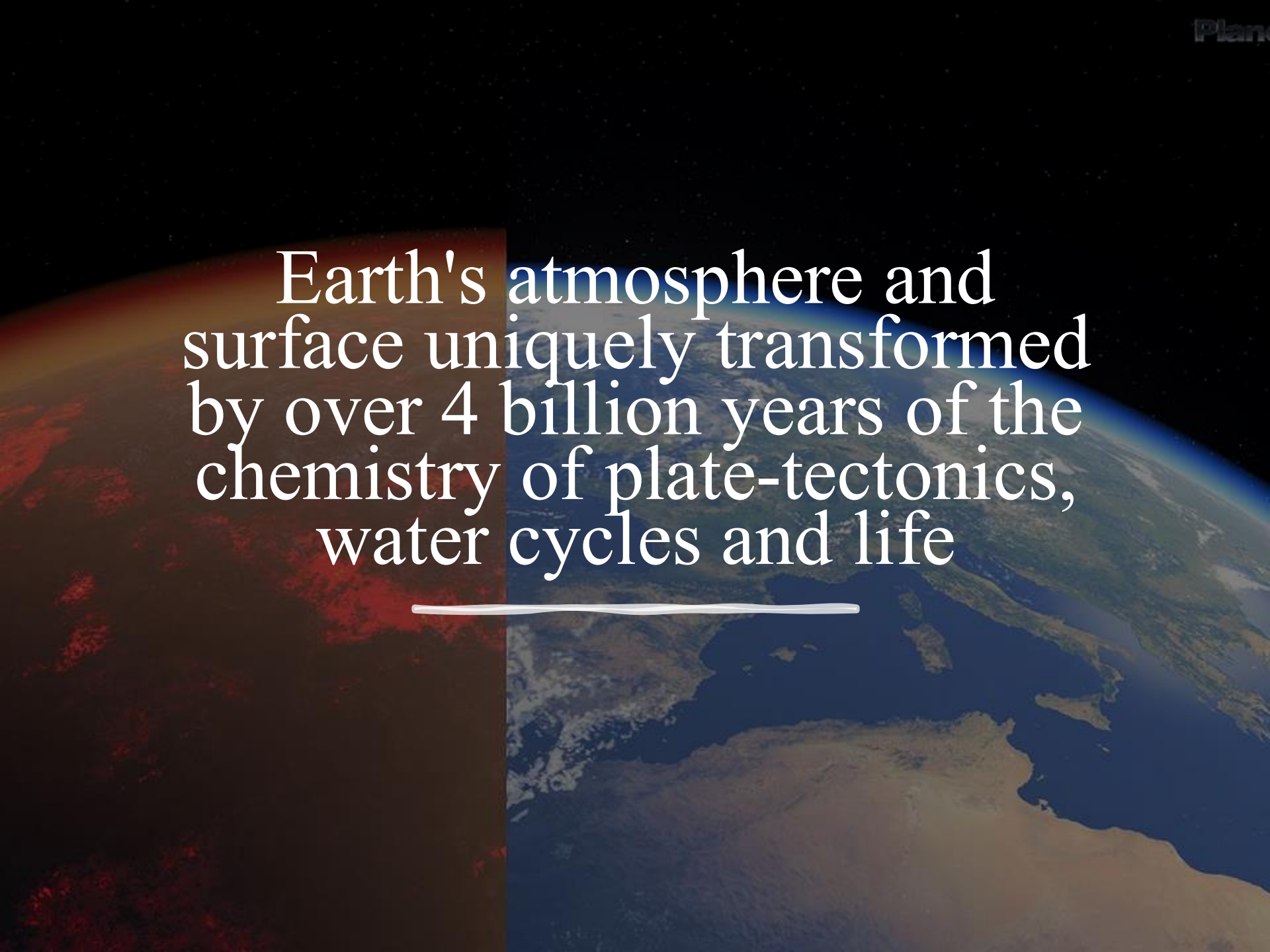

November 2024 Evenings
Looking Southwest
Nov 30
Venus
"Teapot"
Nov 15
SW
EarthSky.org

First planet explored
The Venera Landers

Venus has a hellish environment


You Are Here.




Earth's atmosphere and surface uniquely transformed by over 4 billion years of the chemistry of plate-tectonics, water cycles and life

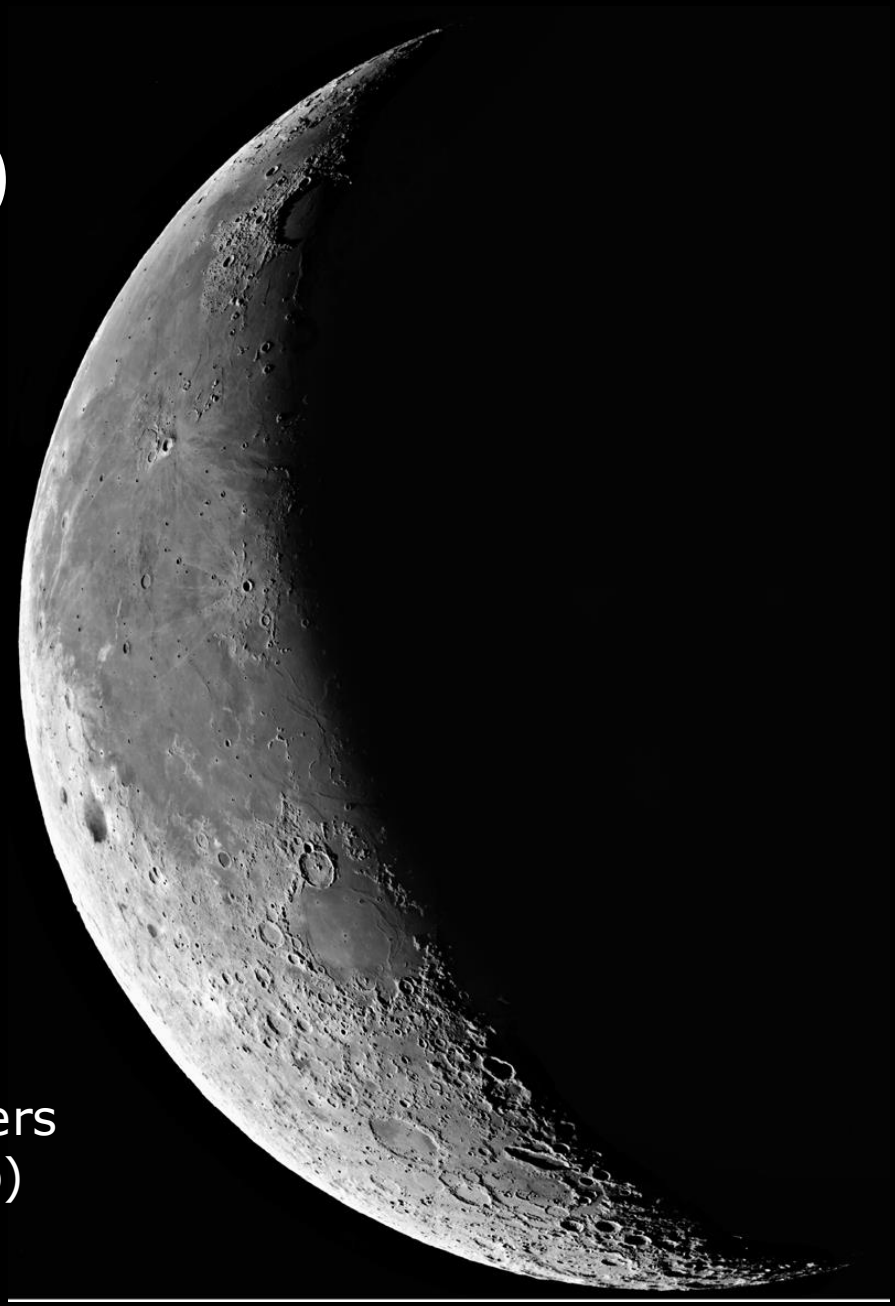
The Earth's Moon (The Moon or Luna)

(1) Surface like Mercury's – airless & cratered.

(1) Very small core – Moon contains very little metals – low gravity: 17% Earth's.

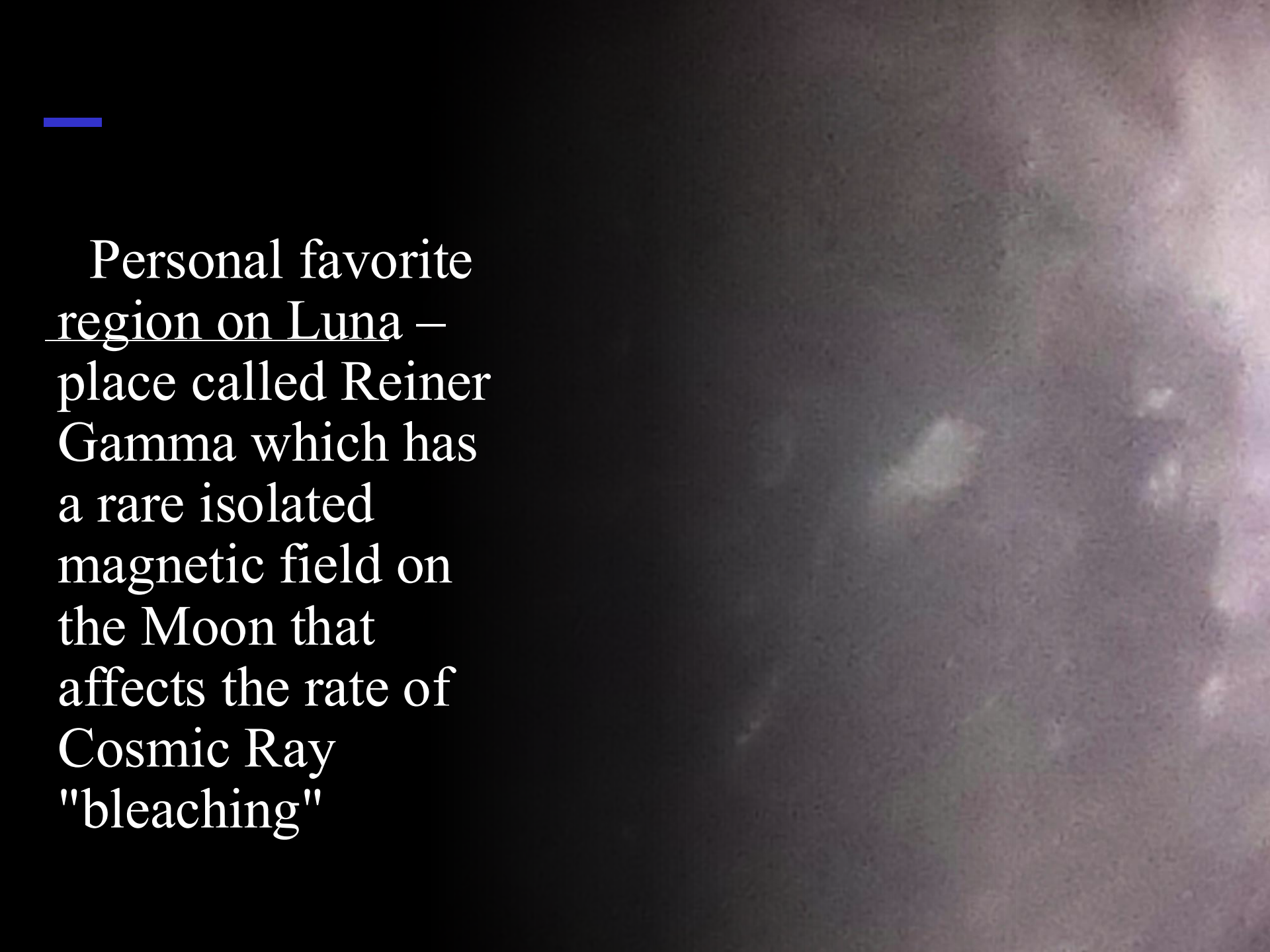
(1) Geologically inactive – few minerals & no volcanism in 3 billion years.

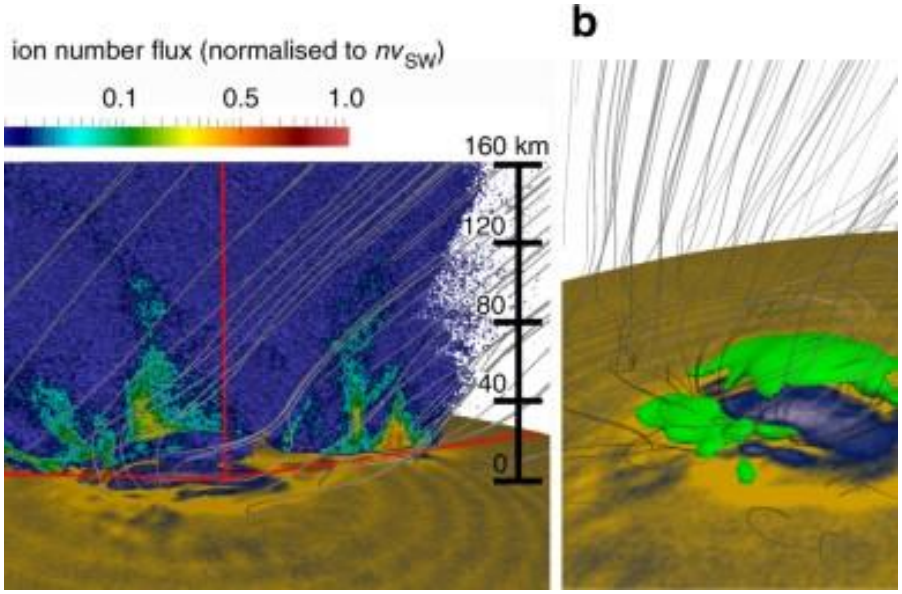
Some interesting very interesting craters
And regions of high brightness (albedo)

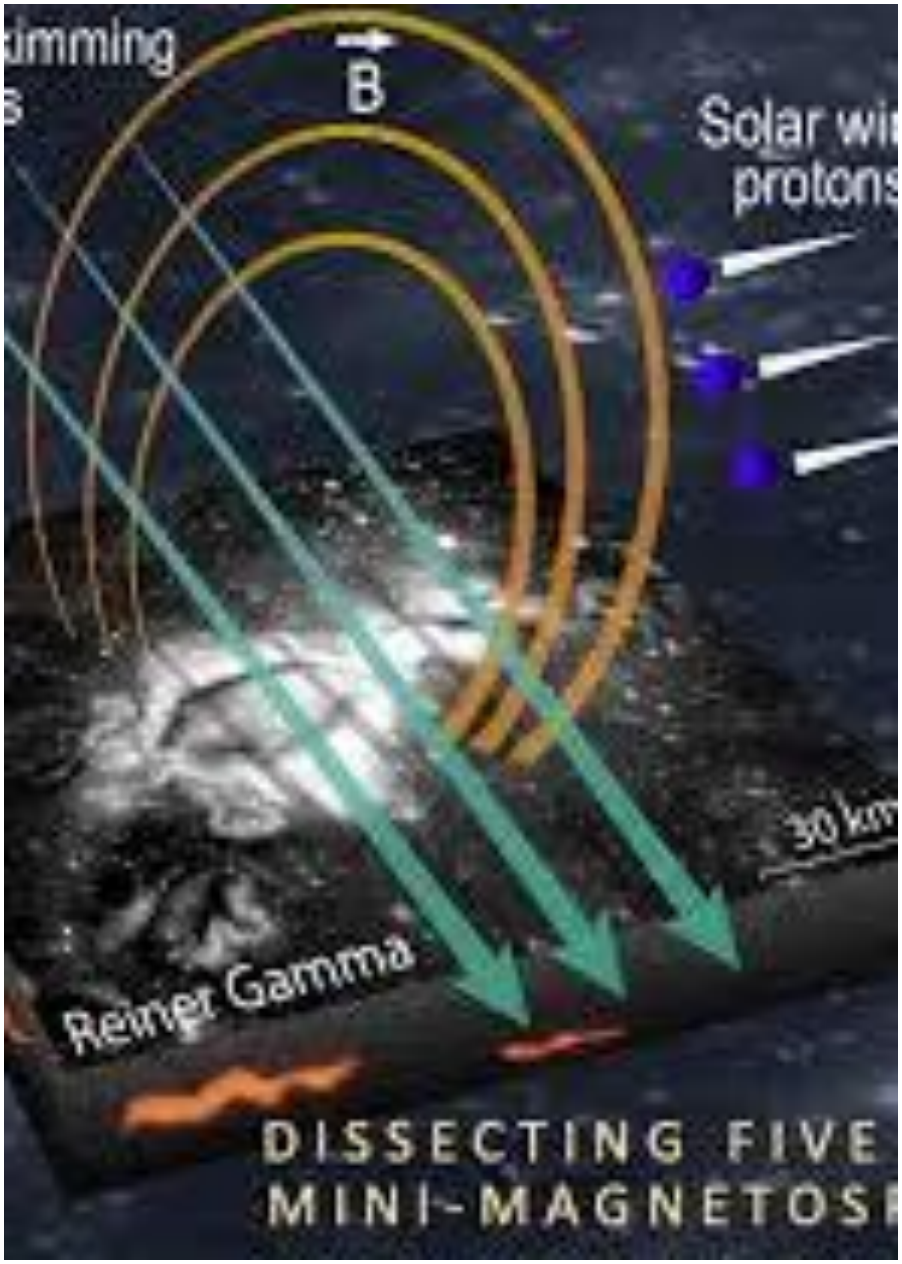


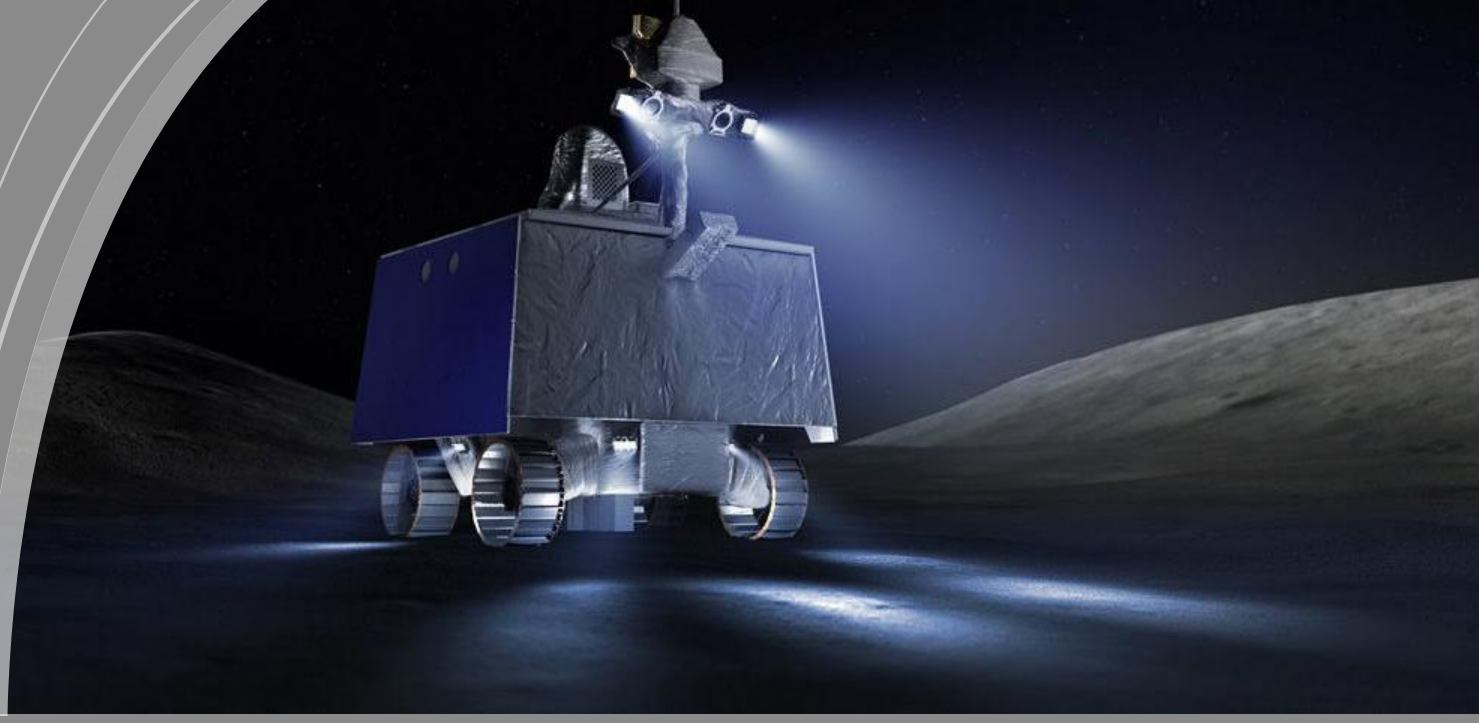
- **Maria- so called** "Seas" are really
- plains of erupted
- basalt with much
- fewer craters (are
- younger) < 3 byo
- & found only on
- Nearside.
- Moon is Tidally Locked with Earth
- Some other regions of high reflectivity
- due to lunar rock (regolith)
- Bleached by billions of years of
- Cosmic rays

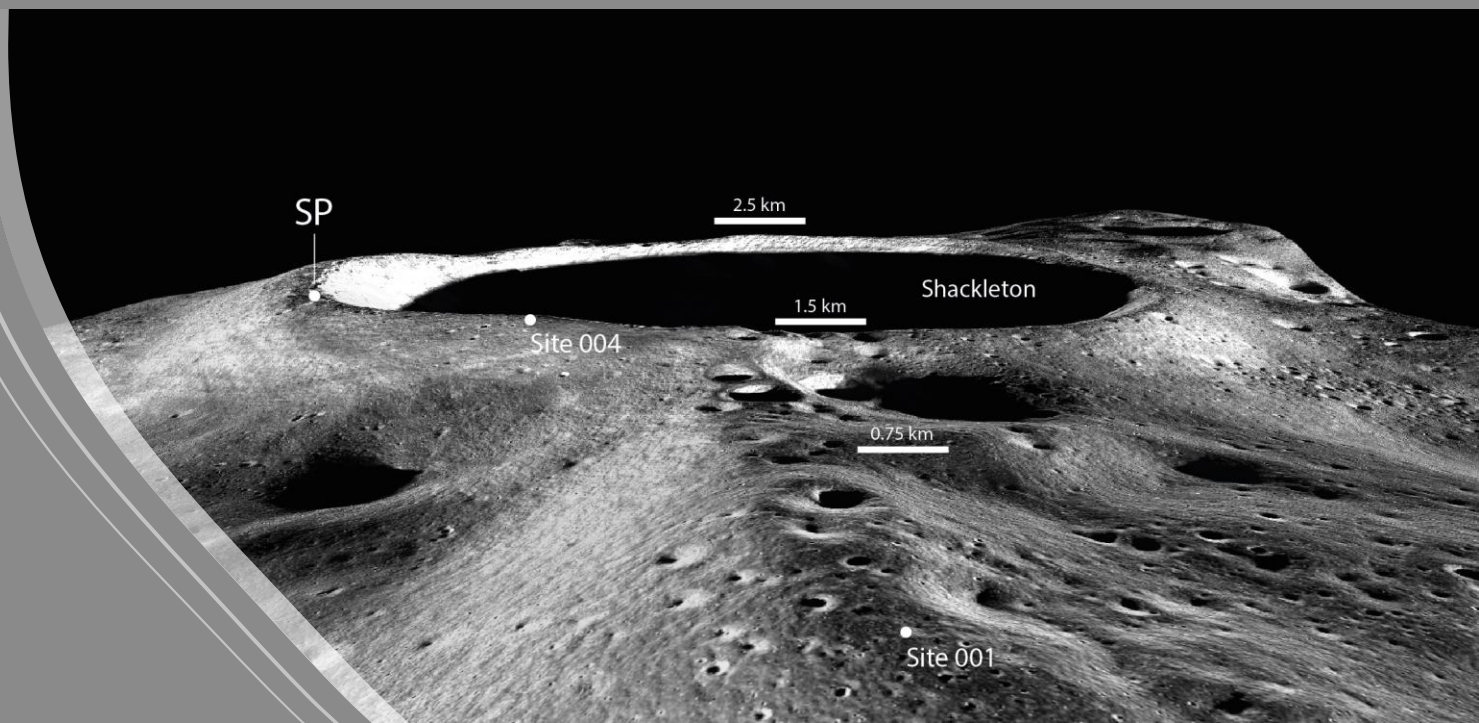
Personal favorite region on Luna – place called Reiner Gamma which has a rare isolated magnetic field on the Moon that affects the rate of Cosmic Ray "bleaching"

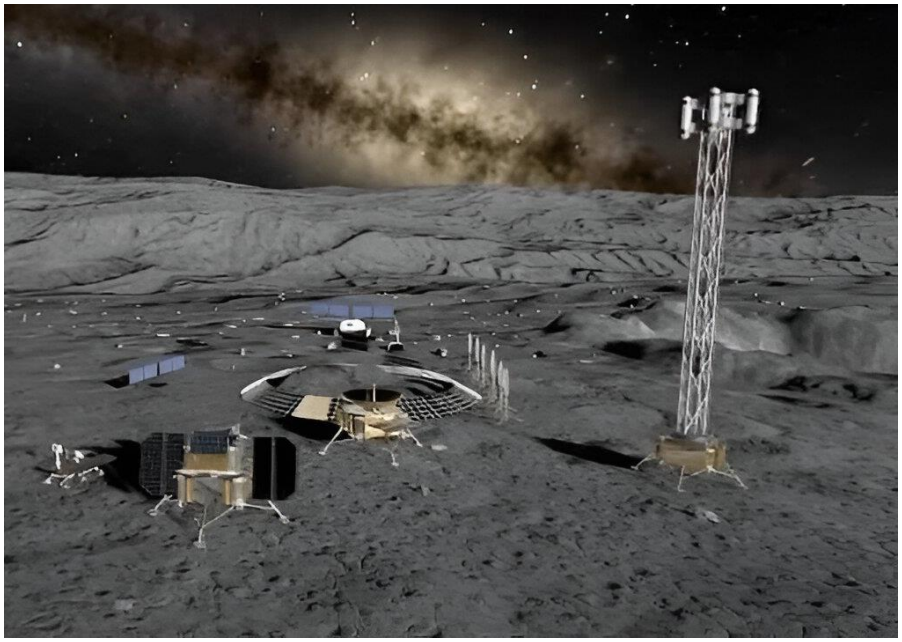


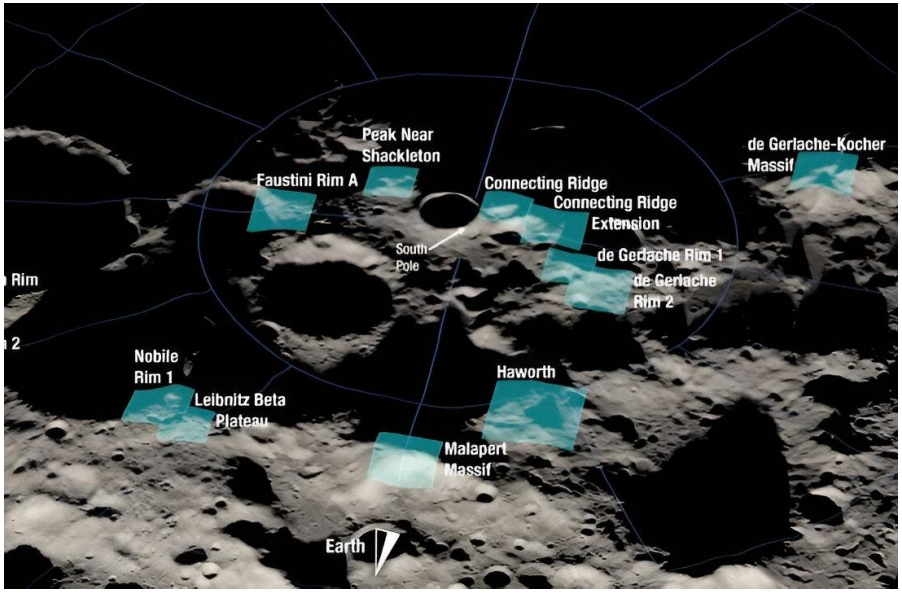

b
ion number flux (normalised to nv_{SW})
0.1
0.5
1.0
160 km
120
80
40
0


B
Reiner Gamma
DISSECTING FIVE
MINI-MAGNETOS

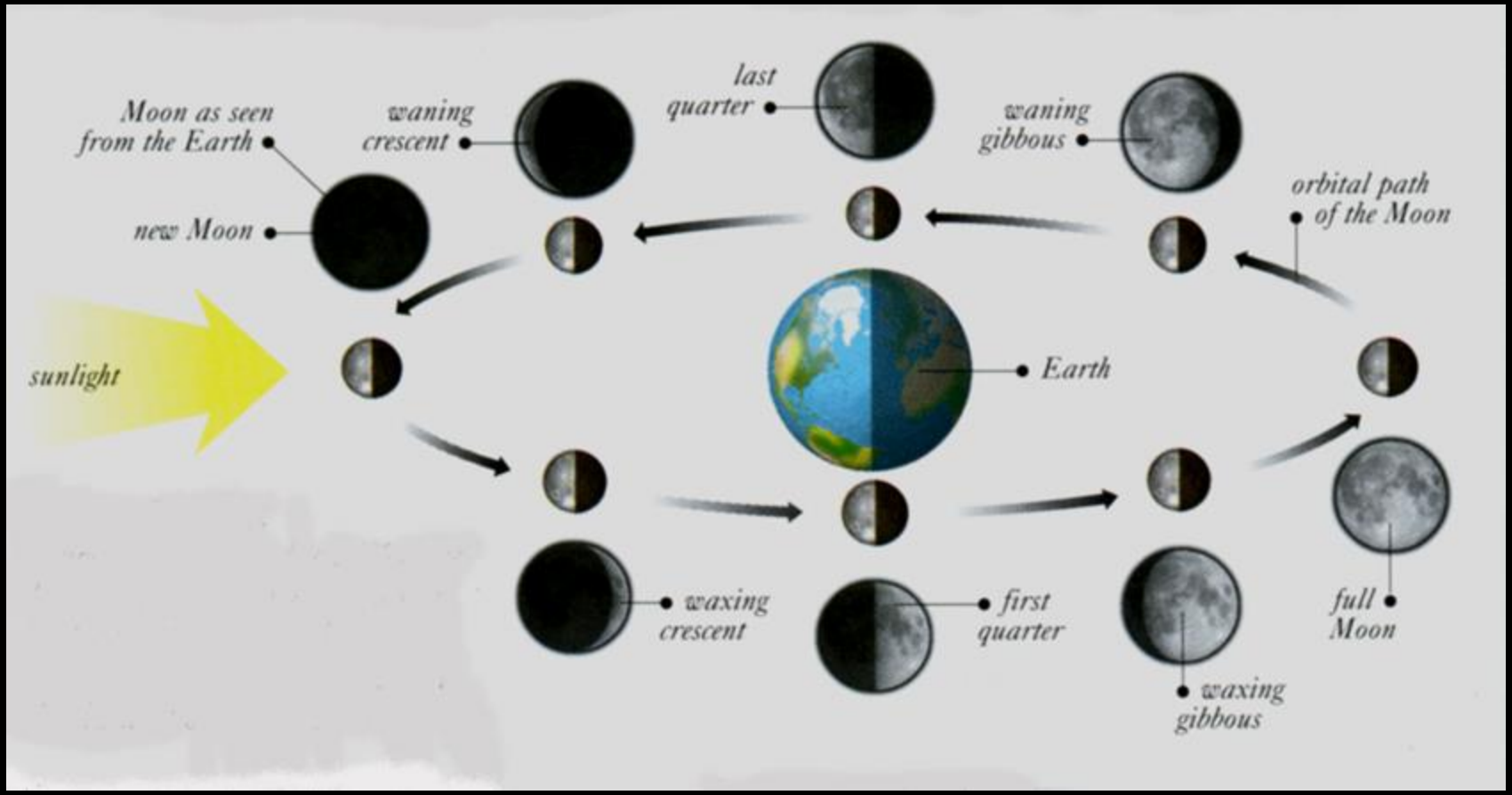



SP
2.5 km
Shackleton
1.5 km
Site 004
0.75 km
Site 001




Peak Near
Shackleton
Faustini Rim A
Connecting Ridge
Connecting Ridge
Extension
de Gerlache-Kocher
Massif
South
Pole
de Gerlache Rim 1
de Gerlache
Rim 2
Rim
2
Nobile
Rim 1
Haworth
Leibnitz Beta
Plateau
Malapert
Massif
Earth

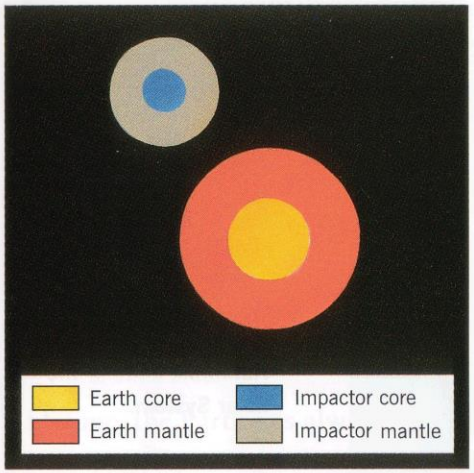
The Moon's Phases



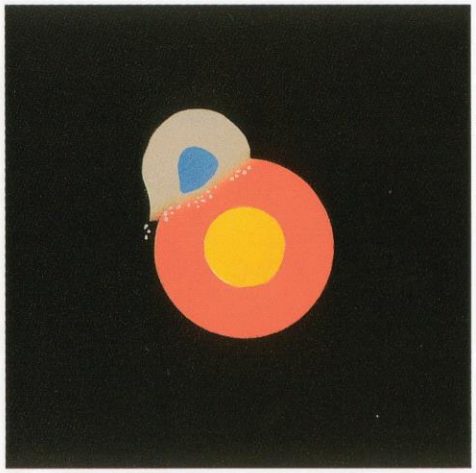
(1) – A Mars–sized object strikes Earth 4.4 bya

(2) The collision liquefies both bodies

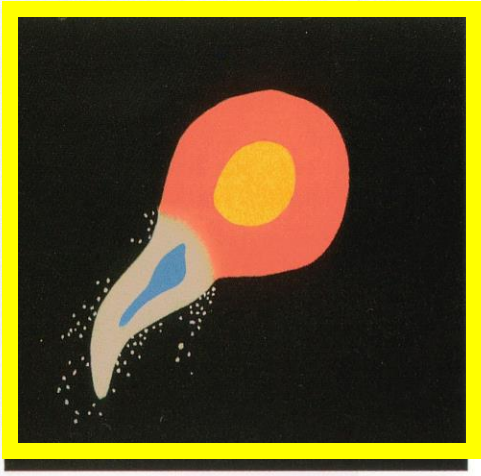
(3) The vapourised impactor orbits Earth.



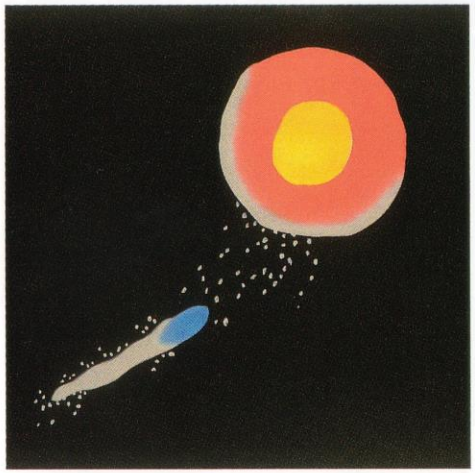
A body about the size of Mars comes close to the Earth, after the Earth has formed its core.



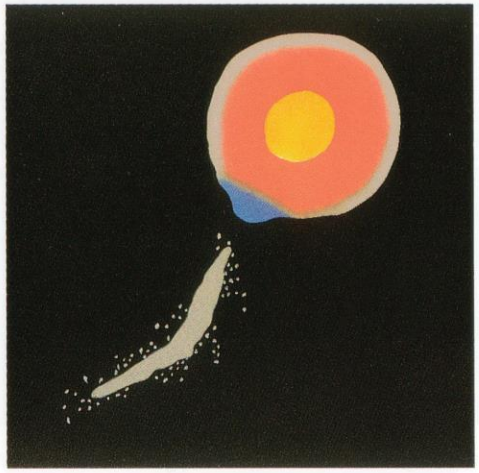
It hits the Earth, vaporising parts of both its own and the Earth's mantle.



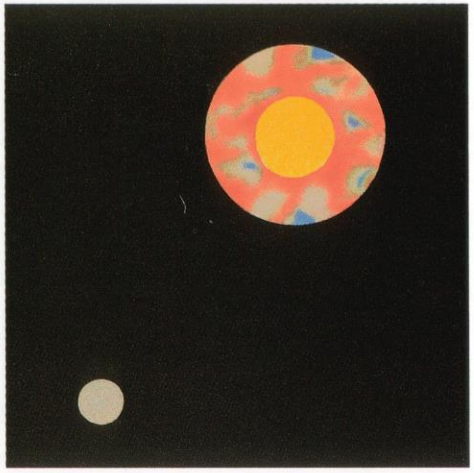
Material is thrown back into space.



Some falls back to the Earth's surface.



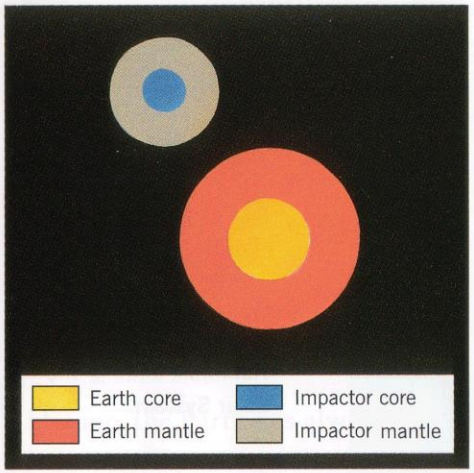
A disk of material is left orbiting the Earth.



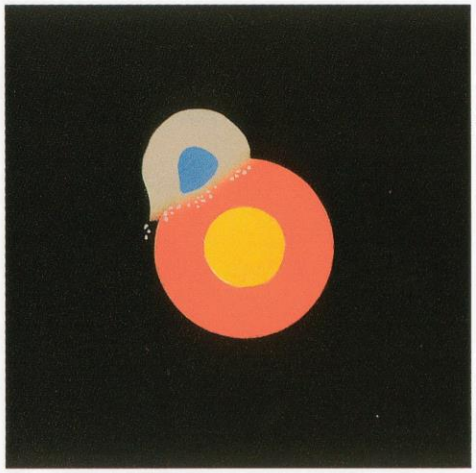
The Moon forms from the disk.

(4) The impactor's core falls back to Earth.

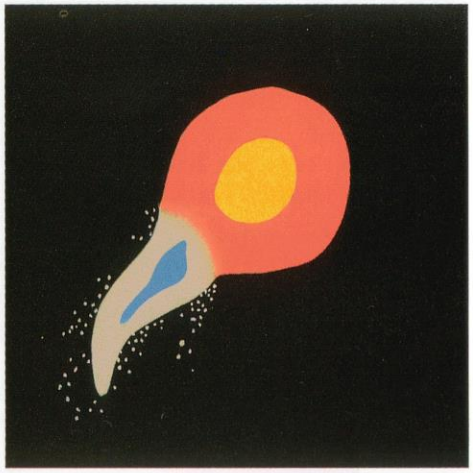
(5) Lighter, mantle material says in orbit.



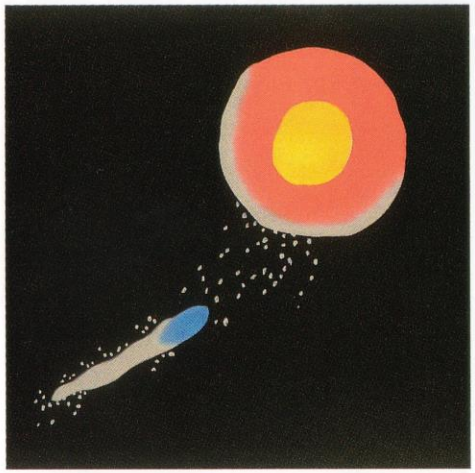
A body about the size of Mars comes close to the Earth, after the Earth has formed its core.



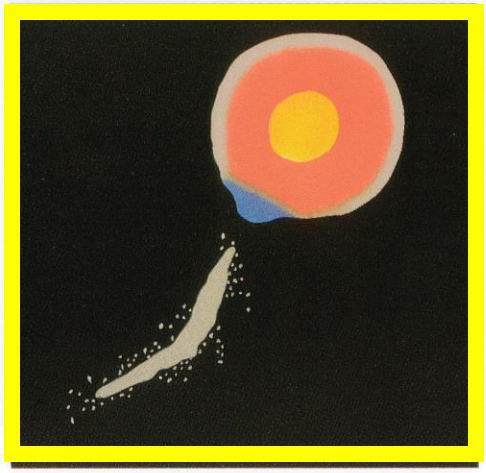
It hits the Earth, vaporising parts of both its own and the Earth's mantle.



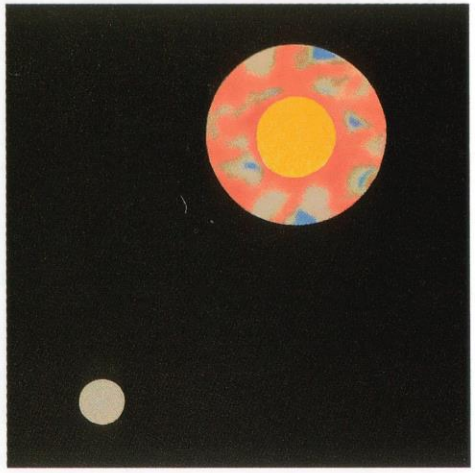
Material is thrown back into space.



Some falls back to the Earth's surface.

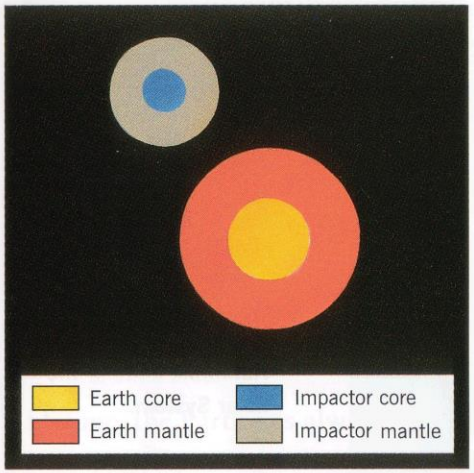


A disk of material is left orbiting the Earth.

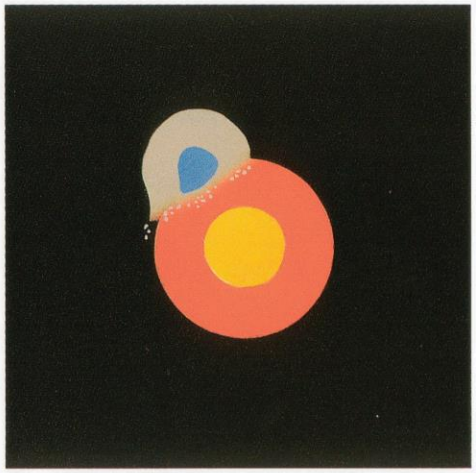


The Moon forms from the disk.

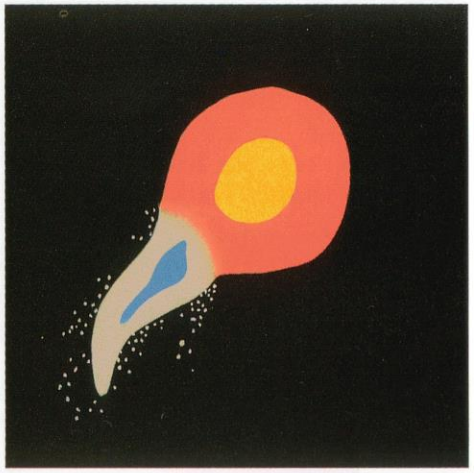
(6) The Moon forms from this lighter material.



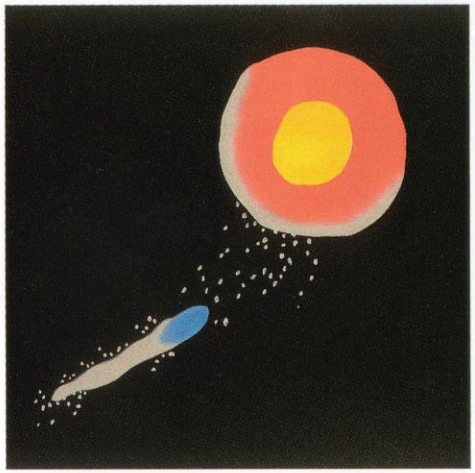
A body about the size of Mars comes close to the Earth, after the Earth has formed its core.



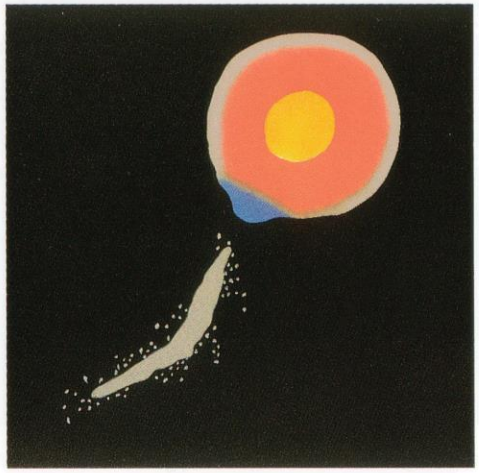
It hits the Earth, vaporising parts of both its own and the Earth's mantle.



Material is thrown back into space.



Some falls back to the Earth's surface.

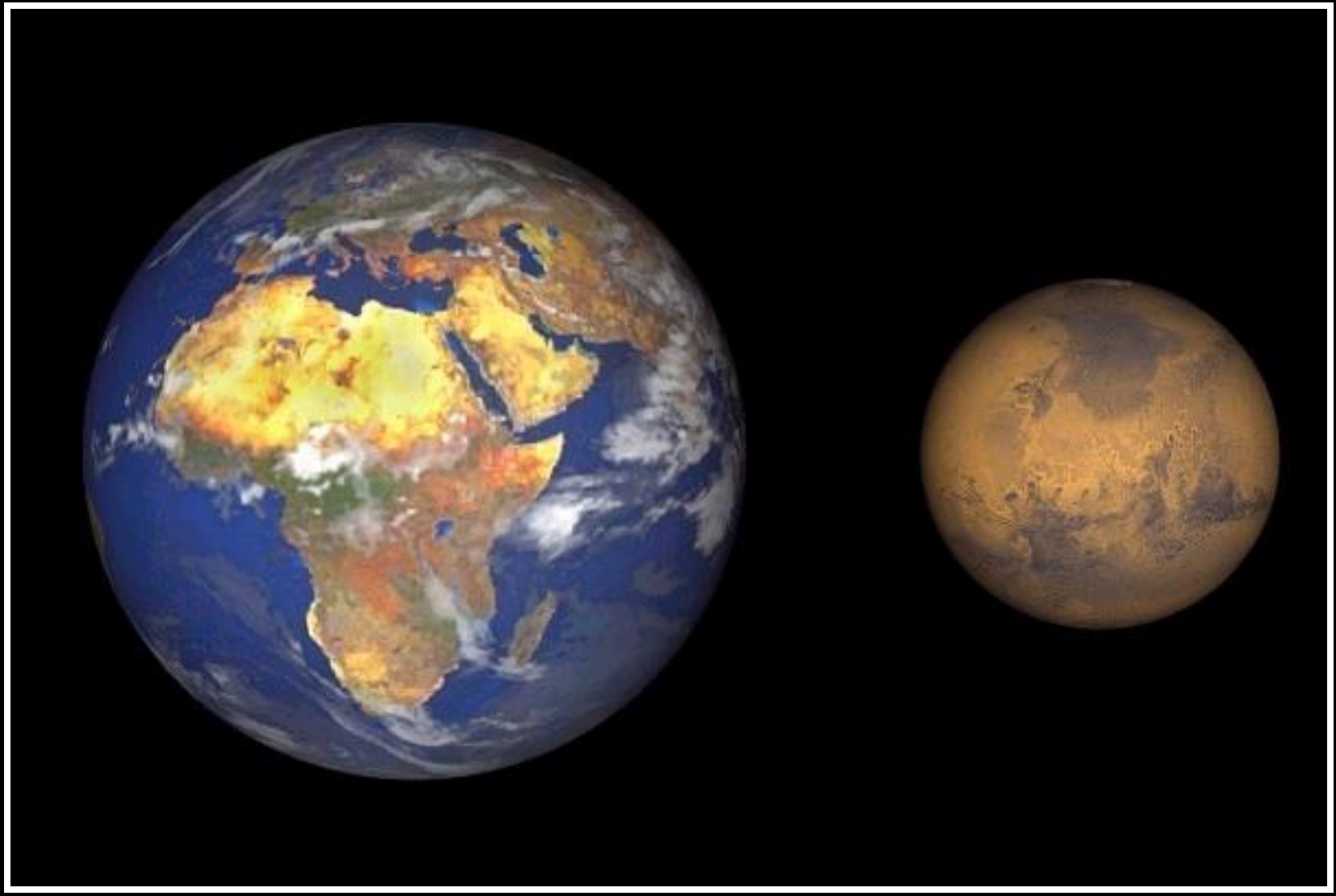


A disk of material is left orbiting the Earth.

The Moon forms from the disk.

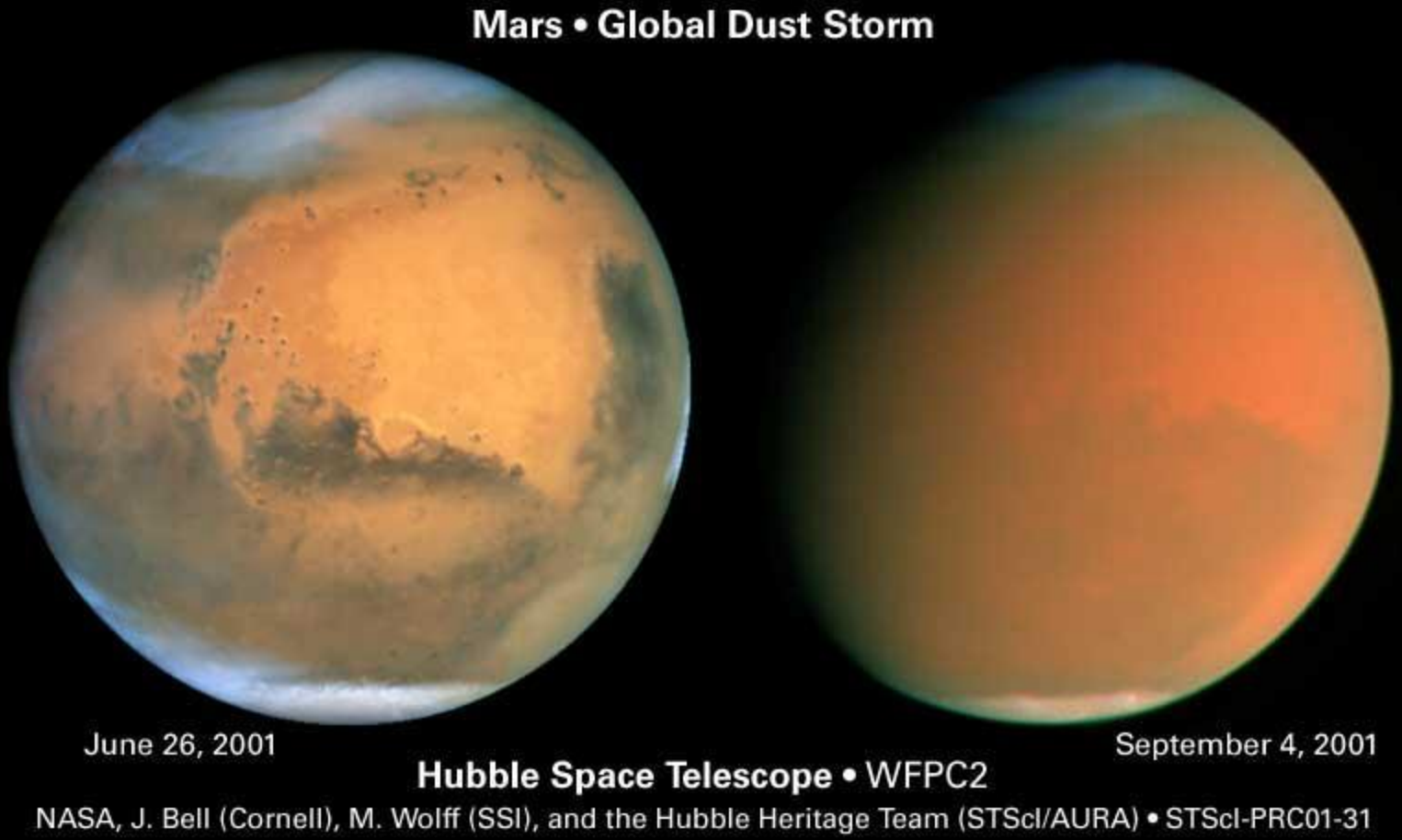
Mars

Earth & Mars size comparison



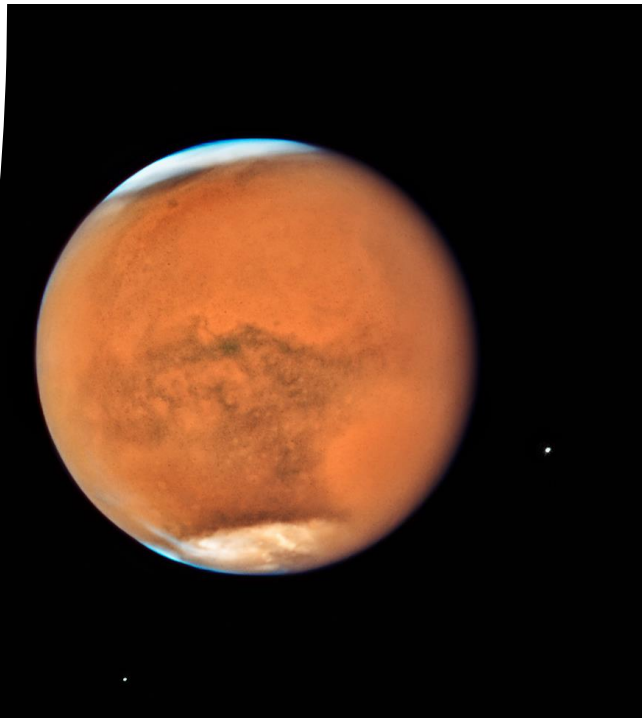
	MARS	EARTH
Land Area	144 m sq. km	148 m sq. km
Distance from Sun	207 – 249 m km	147 – 152 m km
Orbital Period	687 days	365 days
Axial Tilt	25.2º	23.5º
Length of Day	24:39:23	24:00:00
Gravity	0.38 G	1.00 G
Atmos. Contents	CO_2	N_2 & O_2
Atmos. Pressure	7 – 10 millibars	1013 millibars

Global Dust Storms

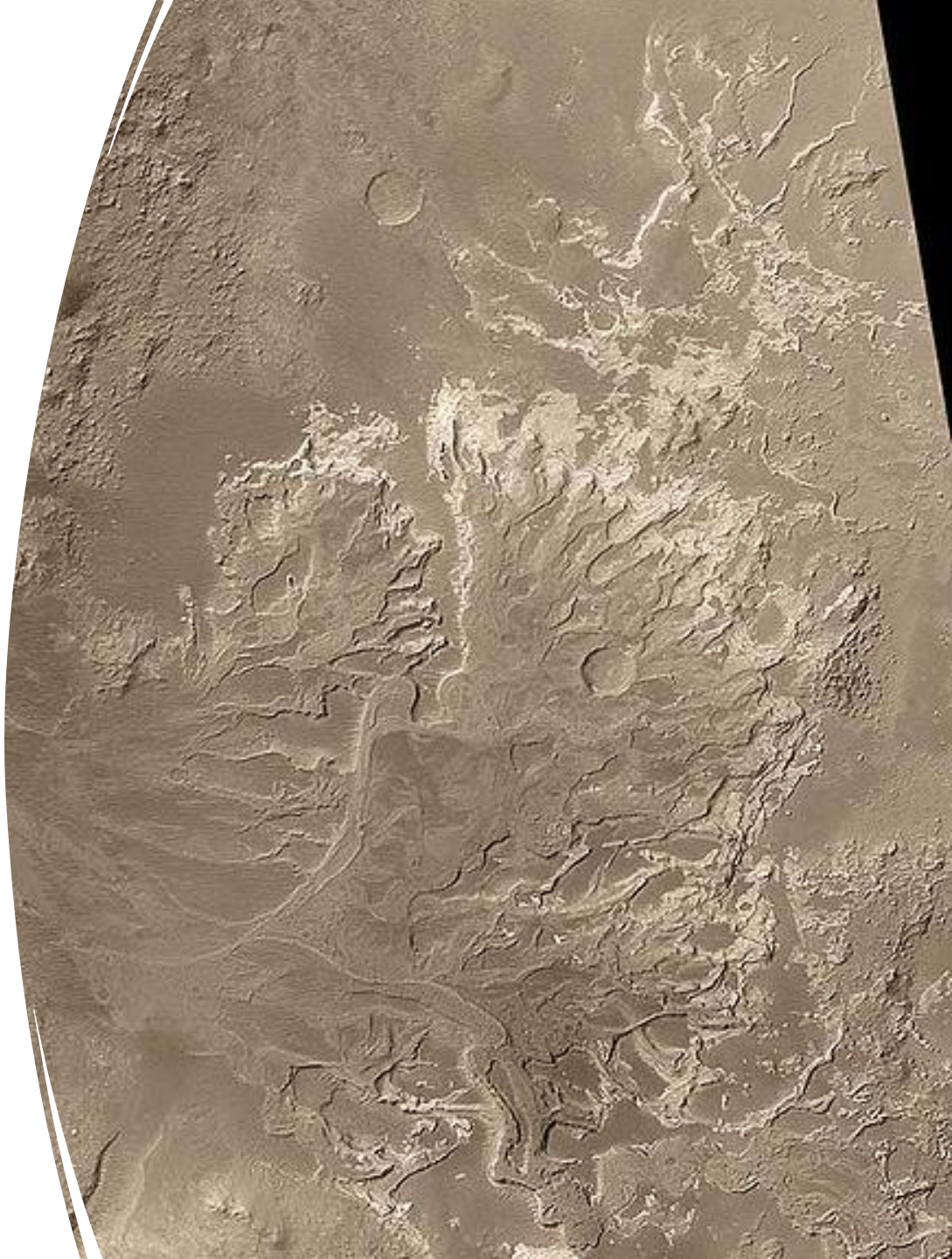


- **Powerful One in Summer2018 –**
- **increased Brightness but killed**
- **the Opportunity**
- **Rover**

- **Why? Because Mars was having**
- **A global dust storm at the**
- Time of its opposition
- Made it brighter than
- Expected
- So Mars'
- Weather is visible
- from Earth!



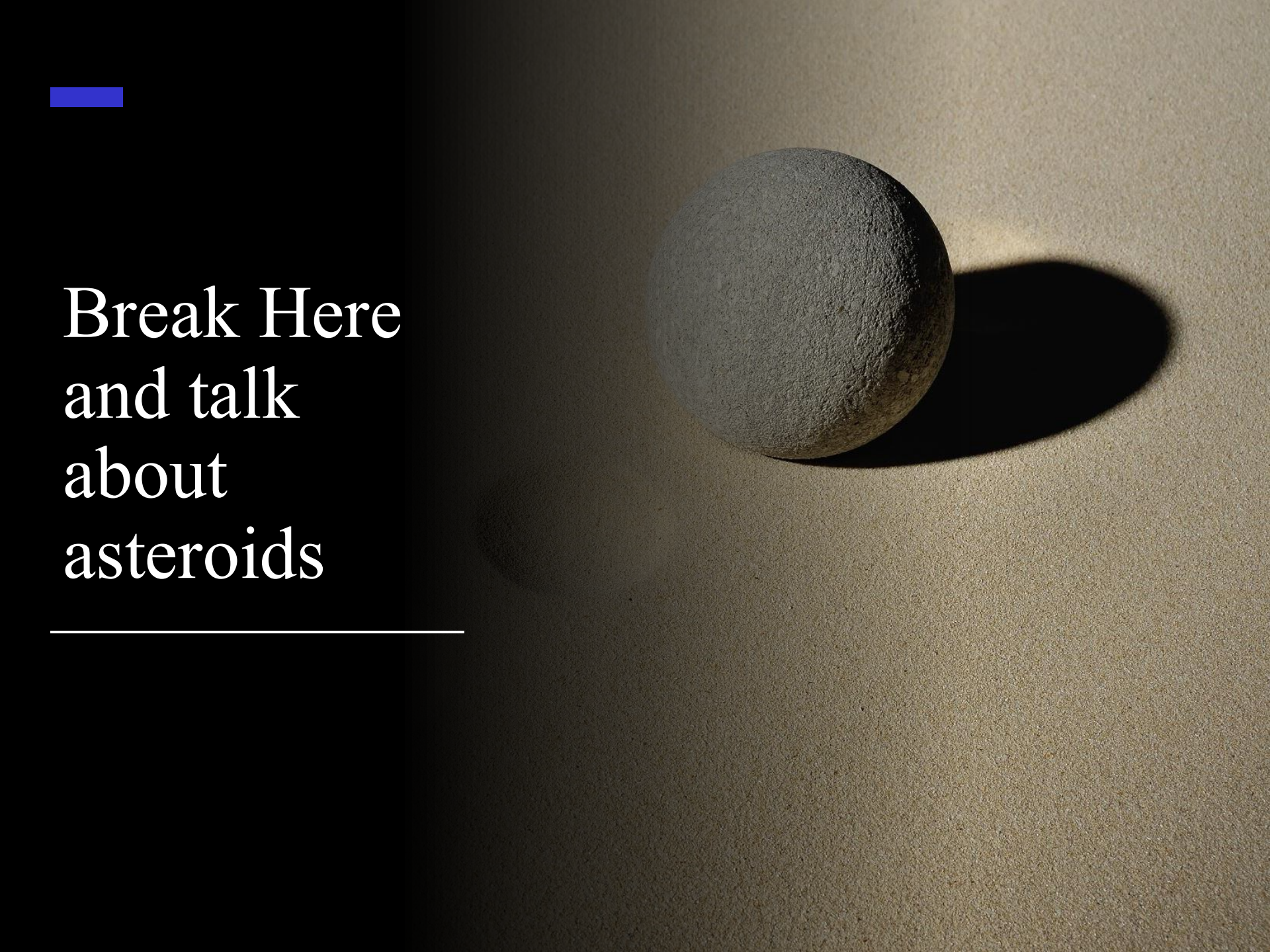
- **Water on Mars.**
  - **Up until recently:**
  - **Ice/Vapour**
  - **Briny liquid?**
  - **Were definitely**
  - **Rivers, lakes,**
  - **seas in**
  - **the past**
  - **Mars is not a wet world currently and conditions are very hostile, 100 times worse than Antartica!**



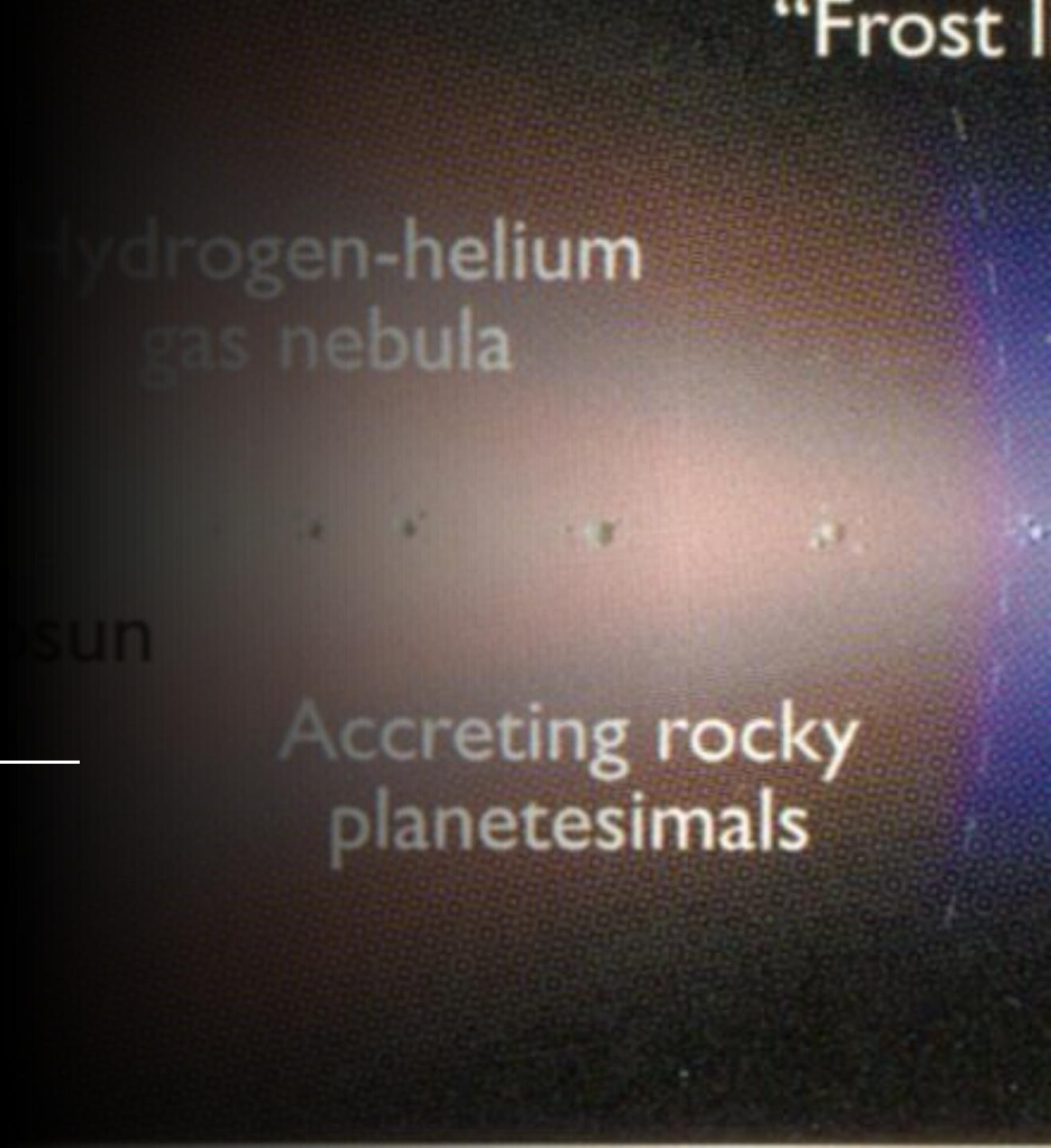

MARTE
LA CONQUISTA DE UN SUEÑ

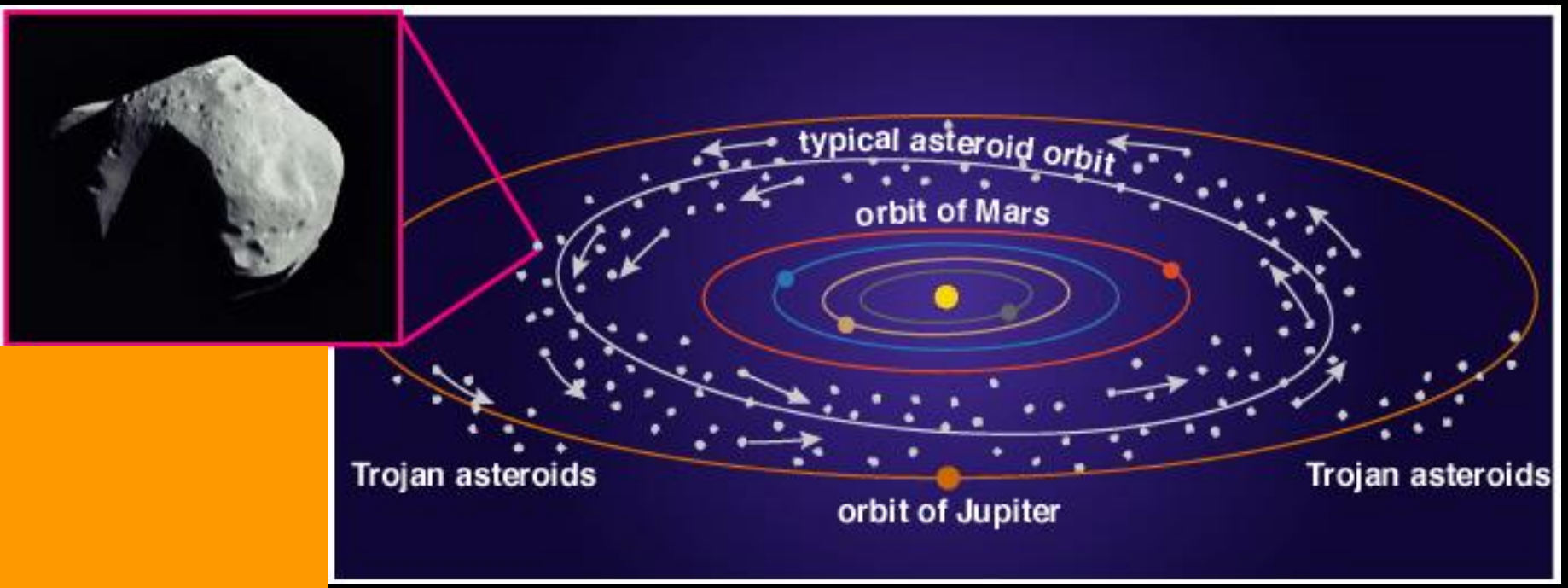

THE DAY MARS INVADED EARTH

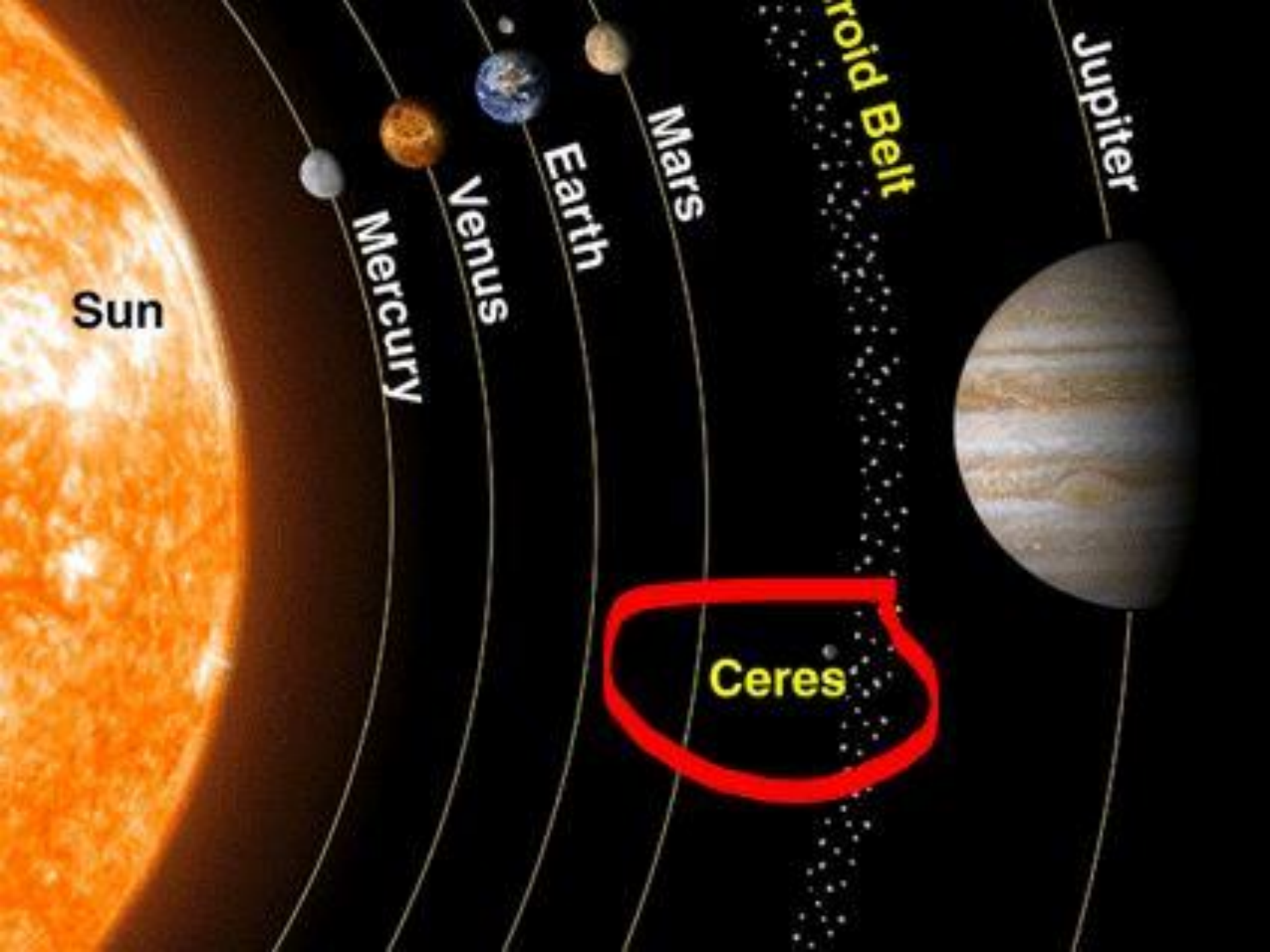
Break Here and talk about asteroids

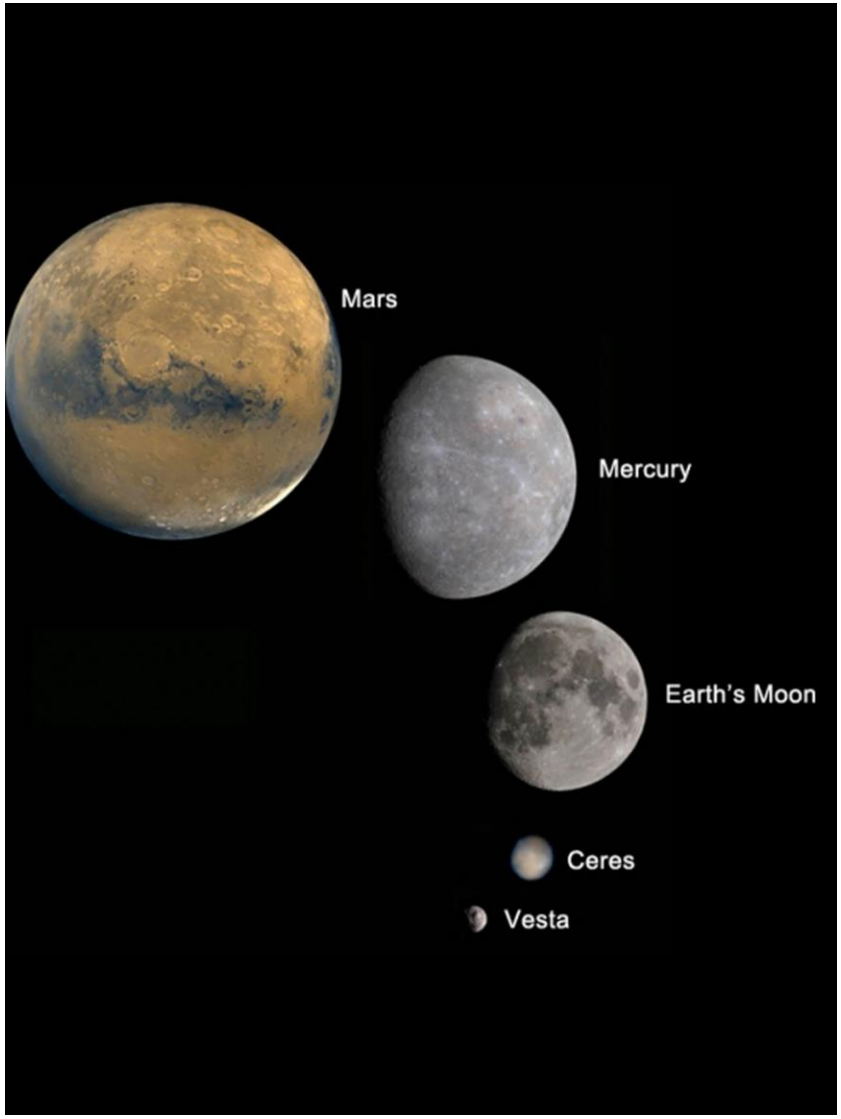


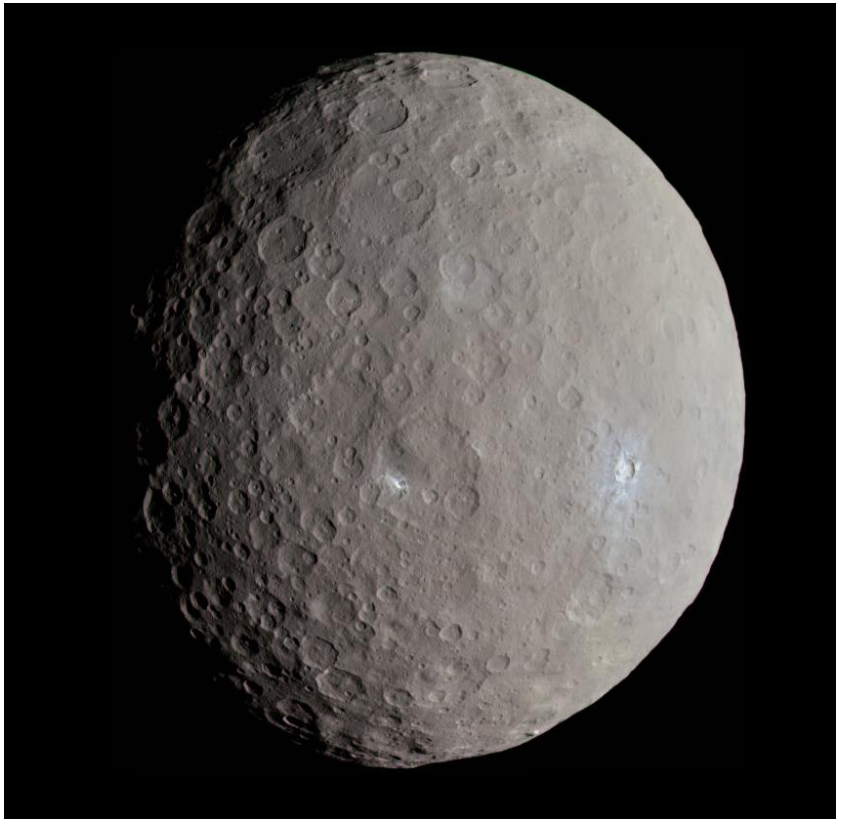
The Asteroids

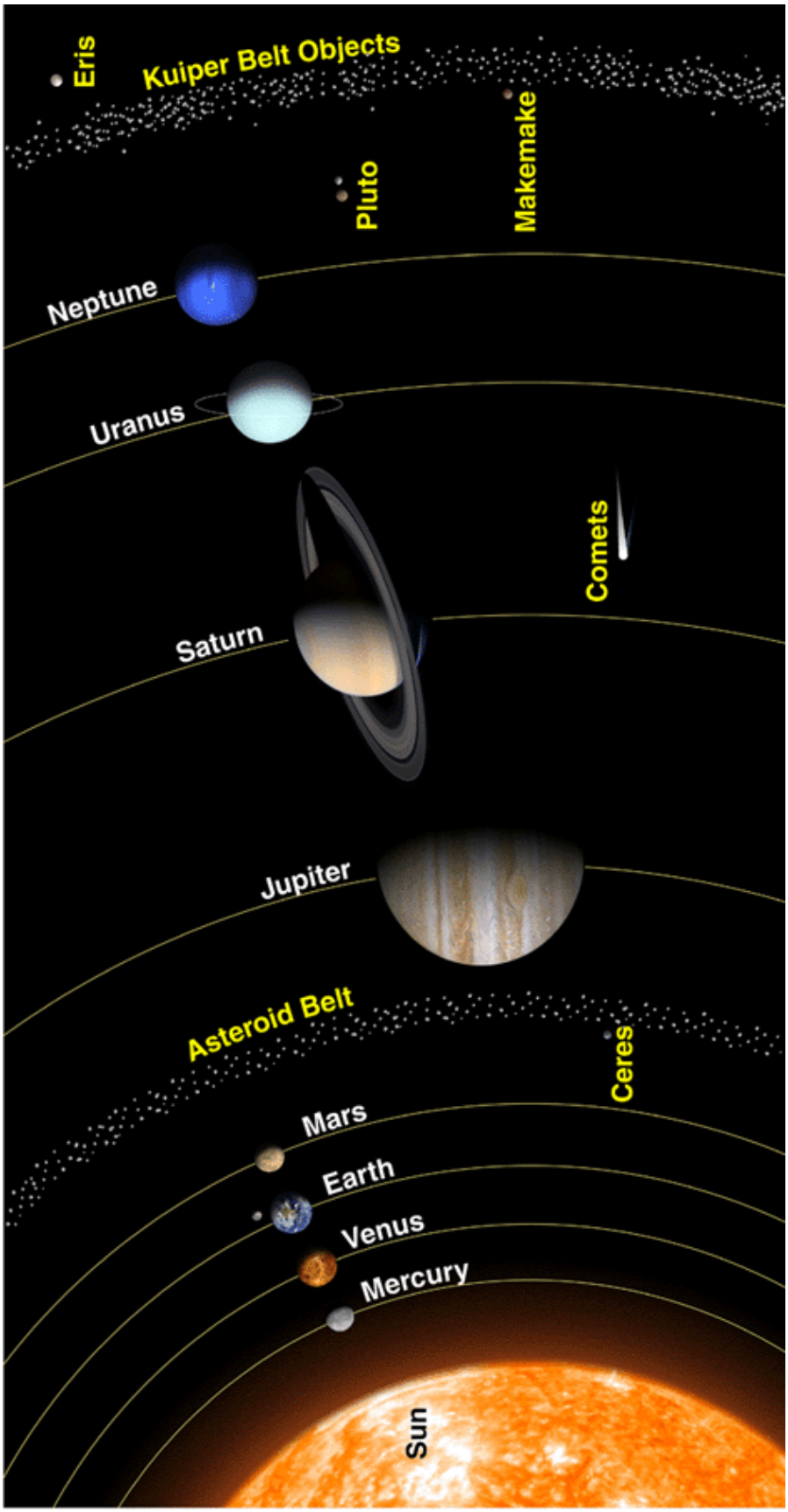


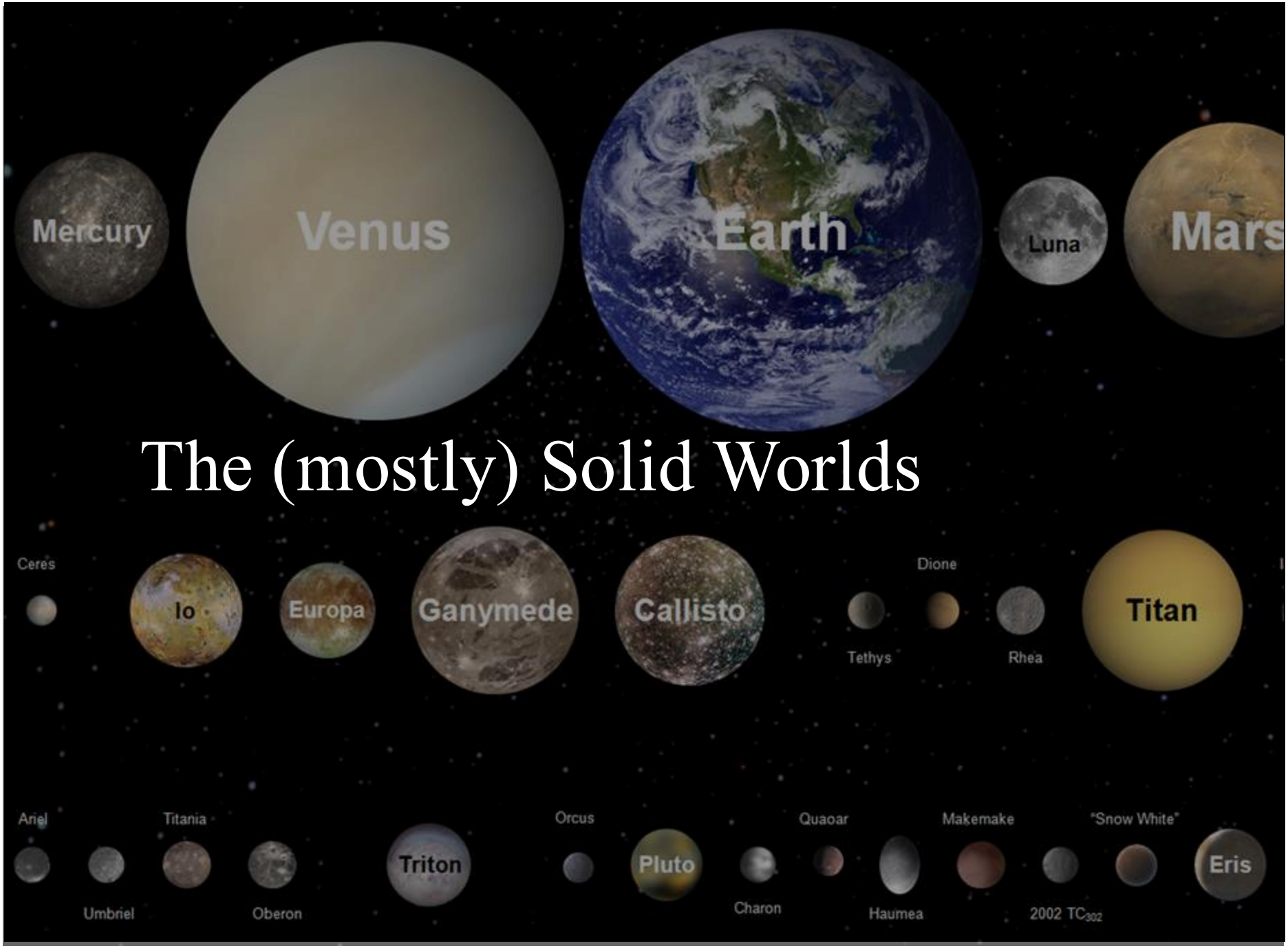

typical asteroid orbit
orbit of Mars
Trojan asteroids
Trojan asteroids
orbit of Jupiter


Sun
Mercury
Venus
Earth
Mars
roid Belt
Jupiter
Ceres


Mars
Mercury
Earth's Moon
Ceres
Vesta

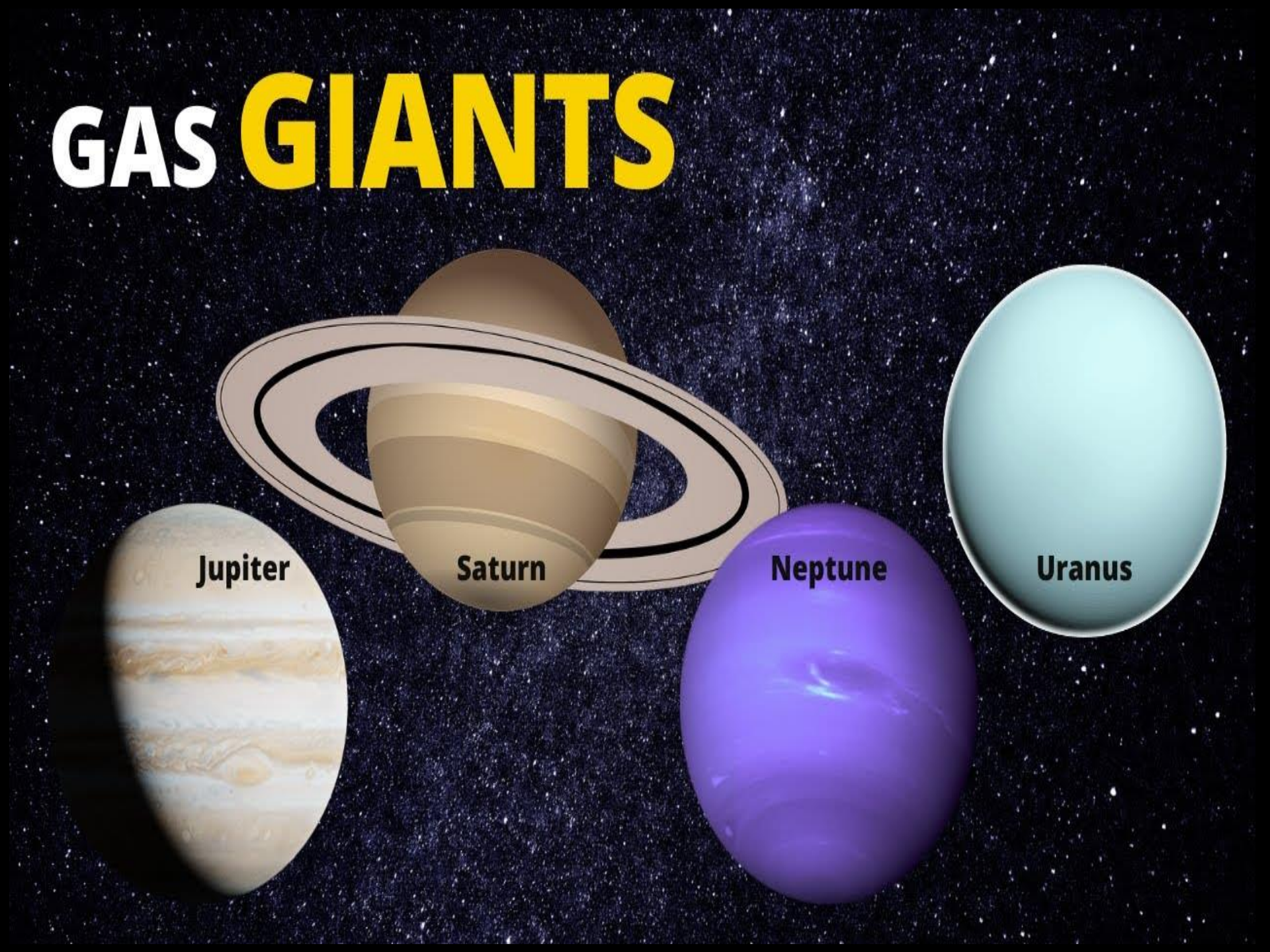


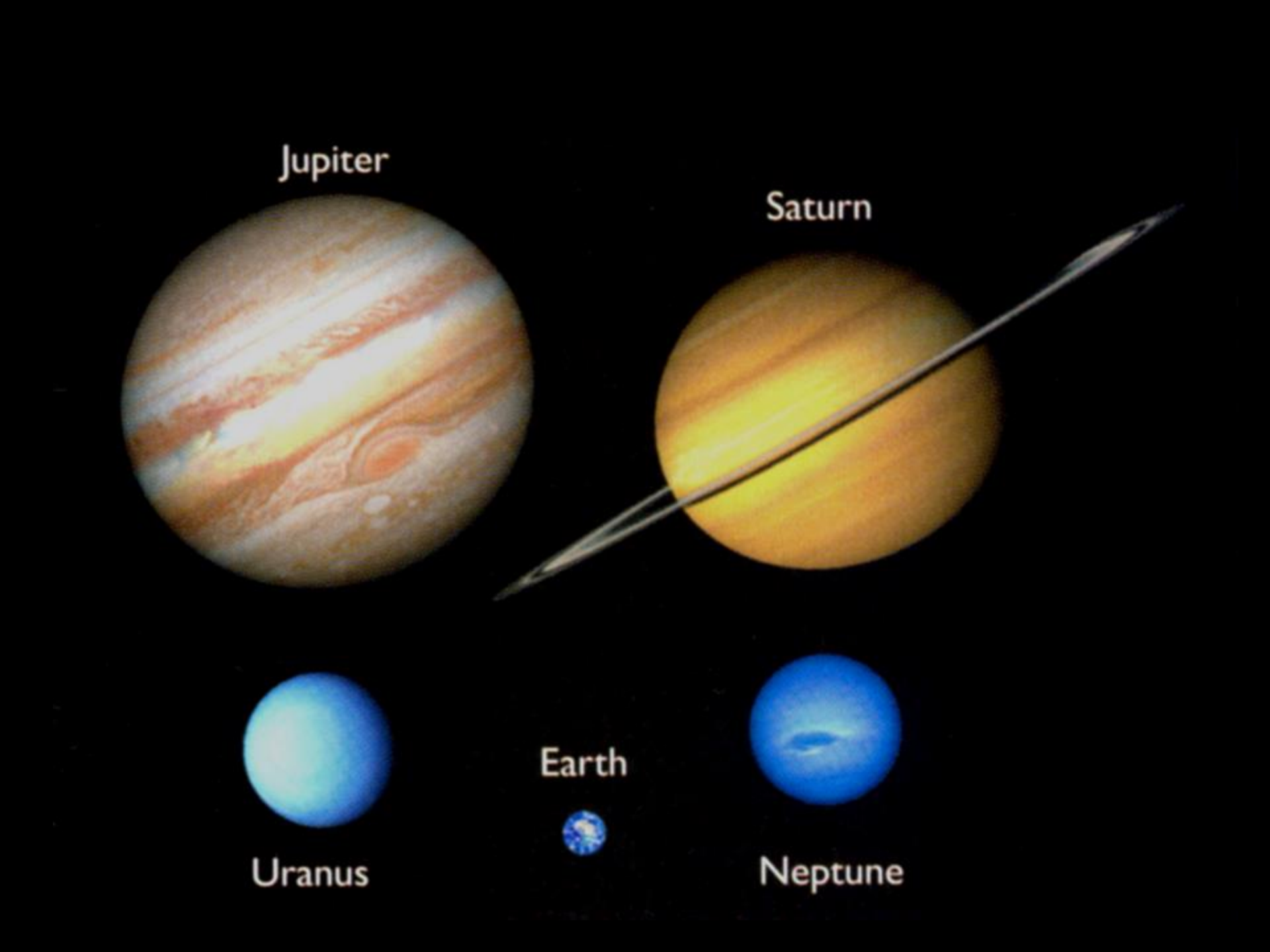

Eris
Kuiper Belt Objects
Pluto
Makemake
Neptune
Uranus
Comets
Saturn
Jupiter
Asteroid Belt
Ceres
Mars
Earth
Venus
Mercury
Sun



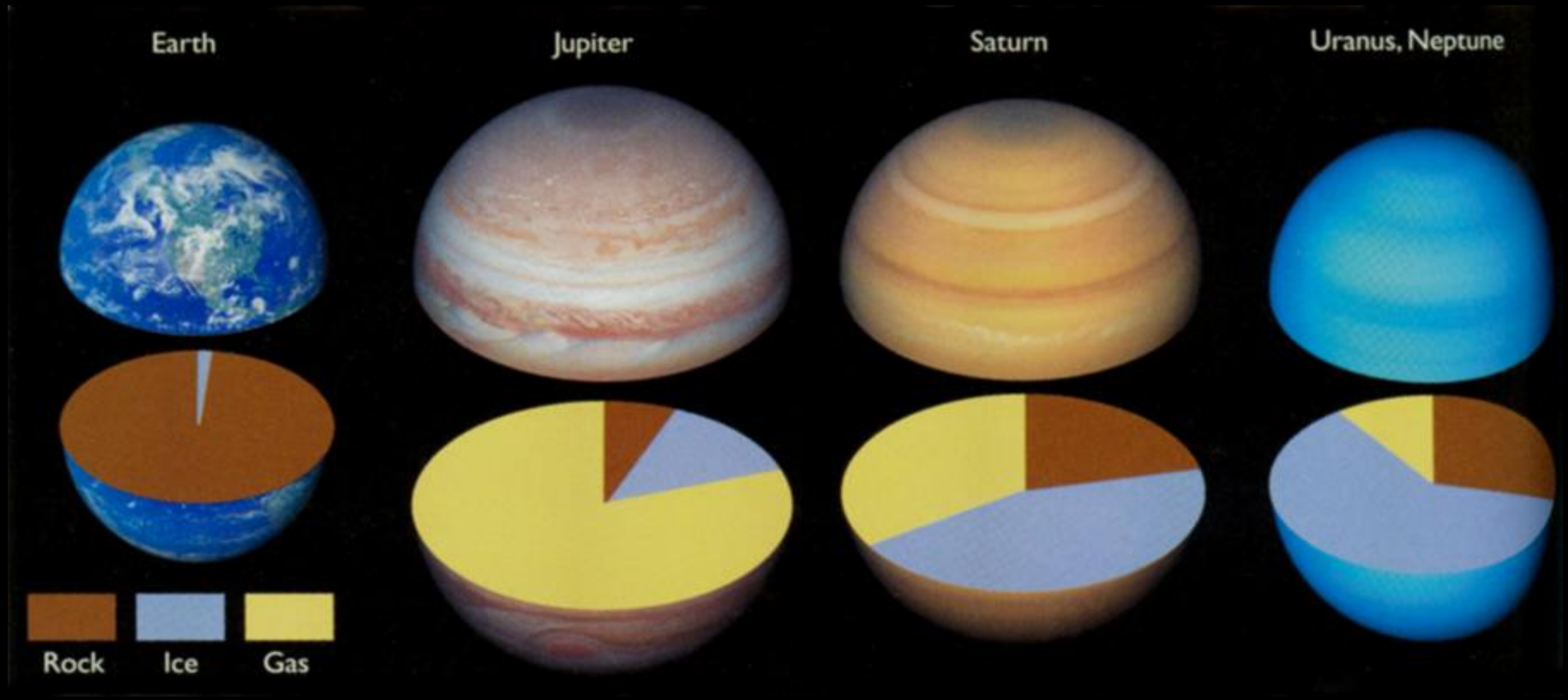
The (mostly) Solid Worlds

GAS GIANTS

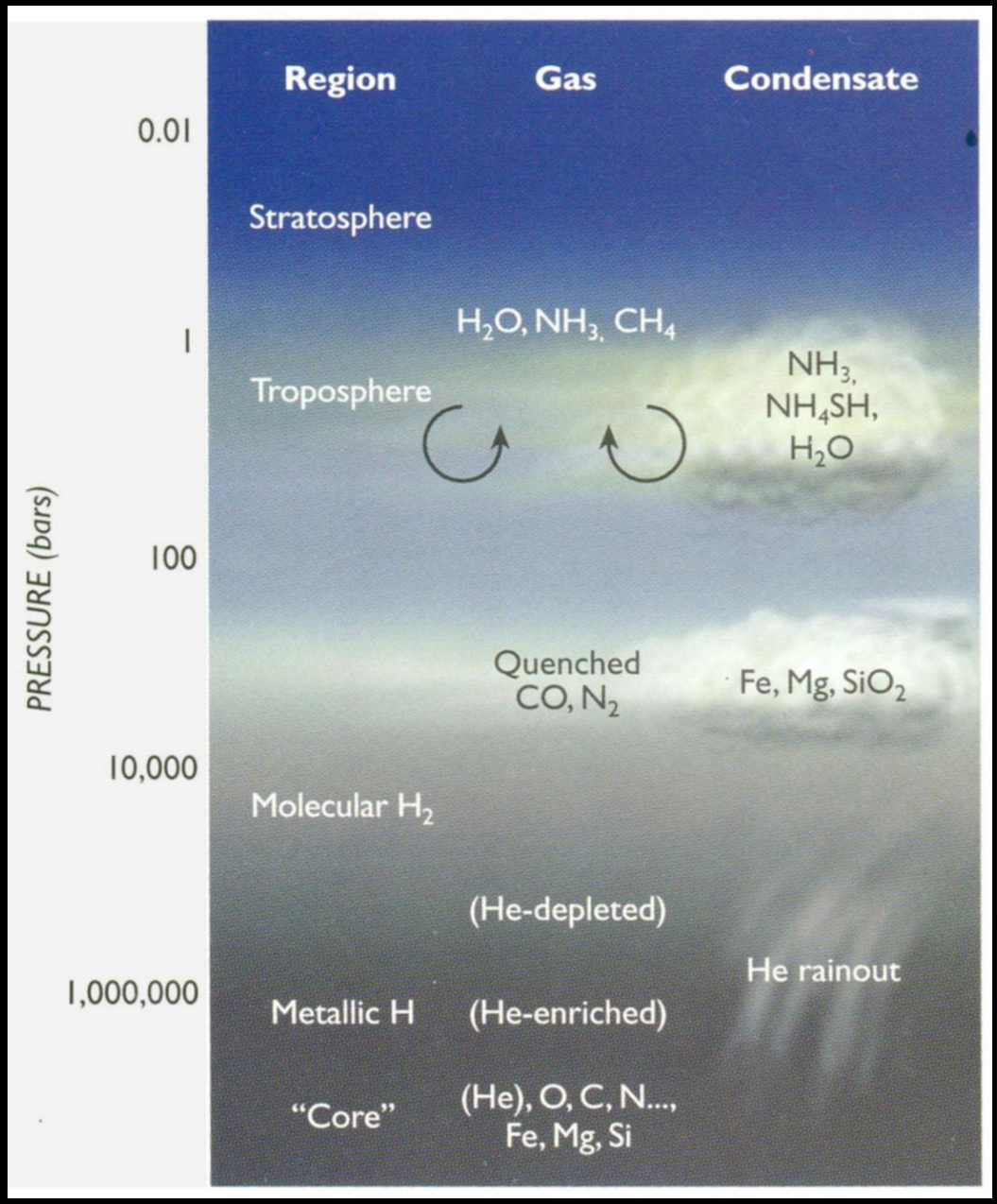



Jupiter
Saturn
Uranus
Earth
Neptune

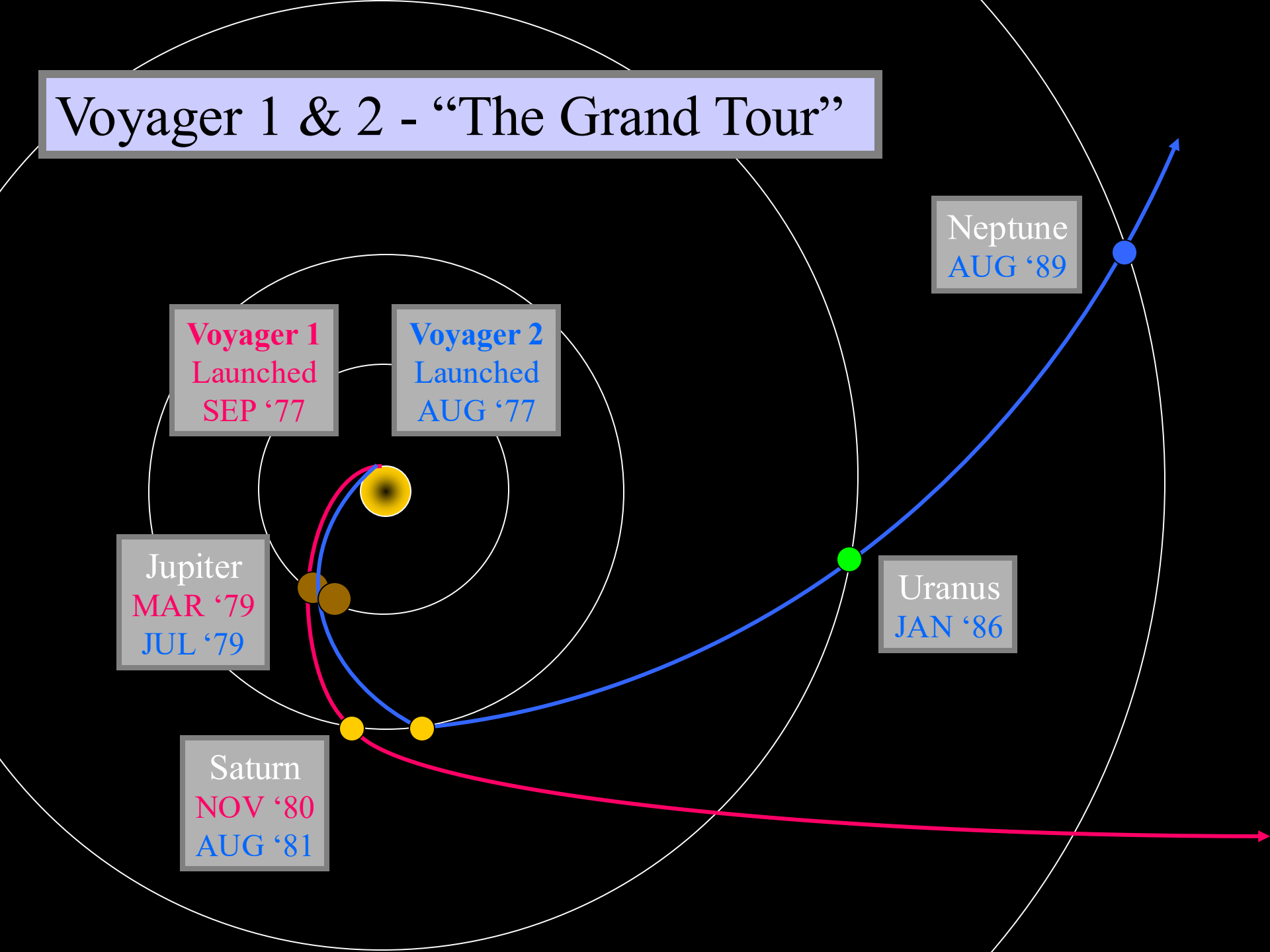
Comparative compositions of planets



Atmosphere & stratiagraphy of a typical giant planet

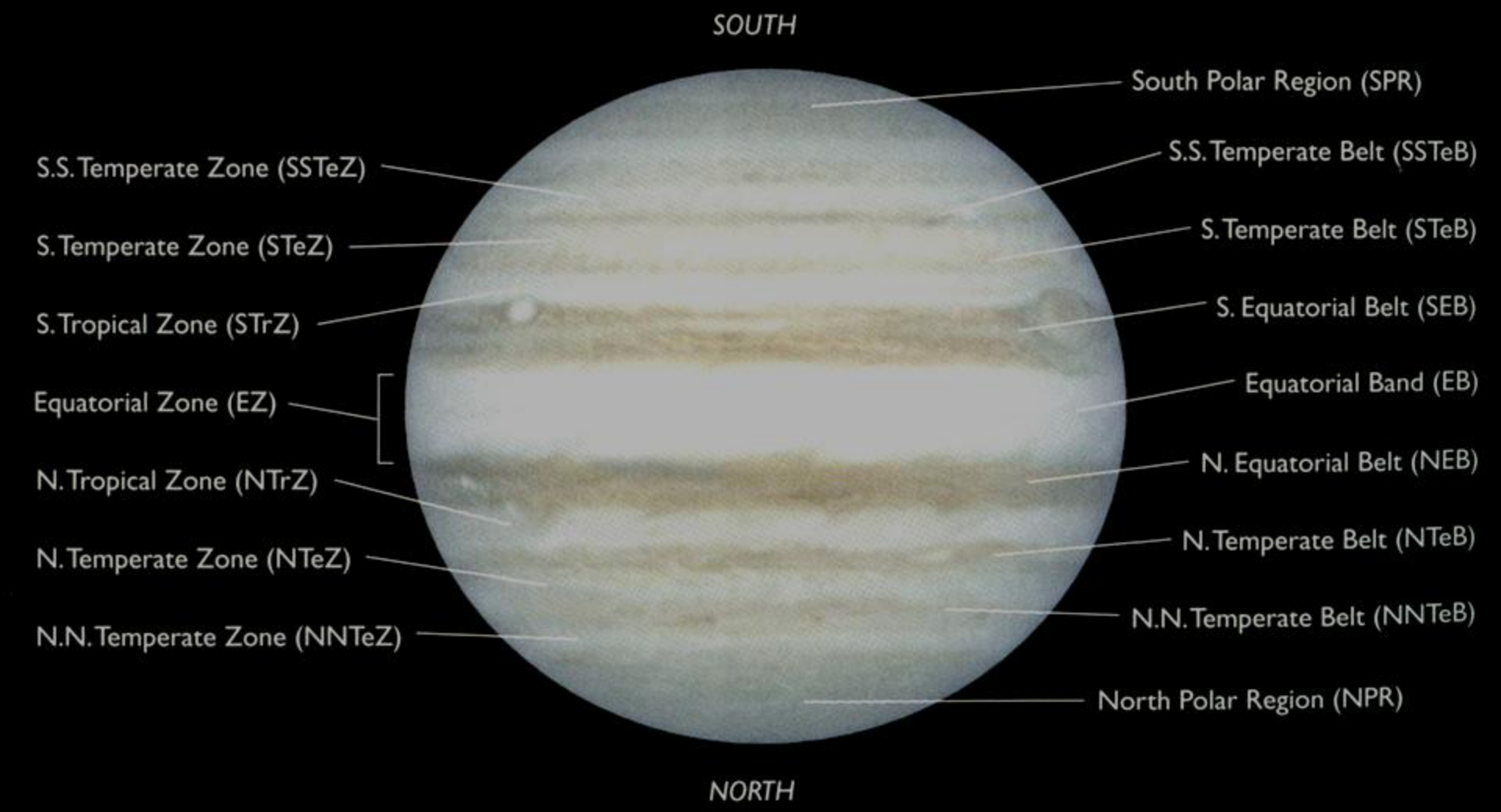


Voyager 1 & 2 - “The Grand Tour”

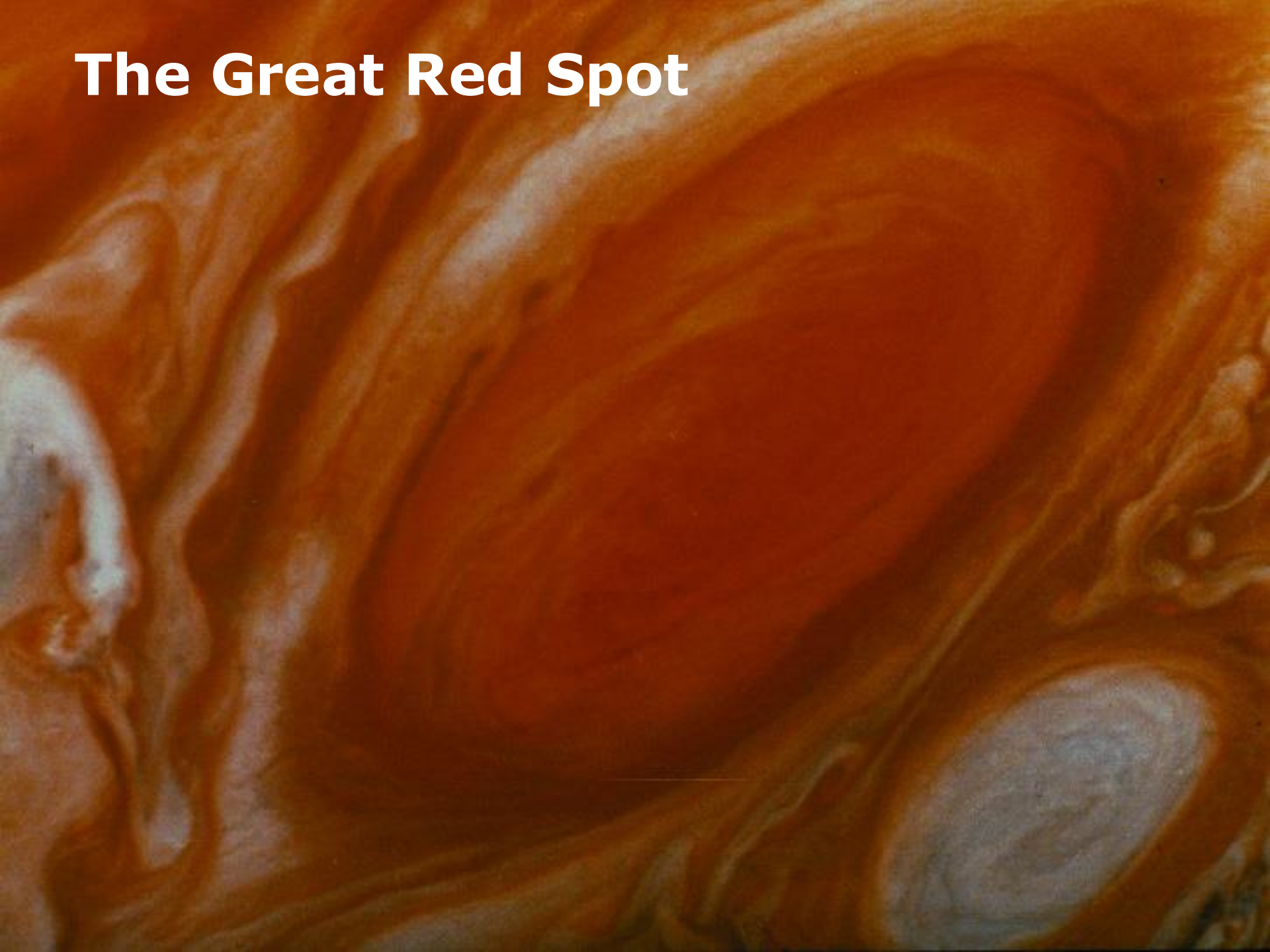


Jupiter

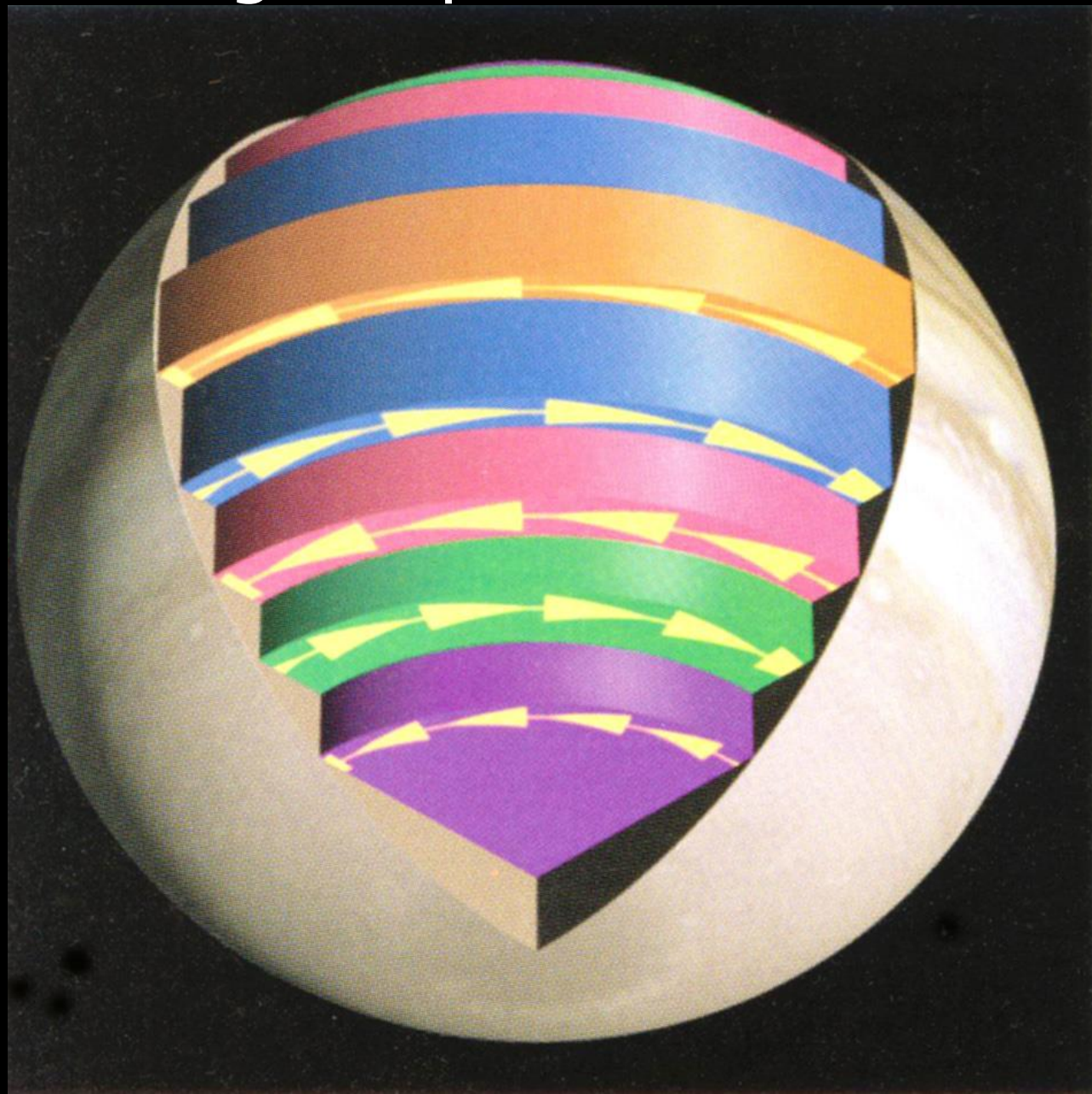
Jupiter's Atmosphere



The Great Red Spot

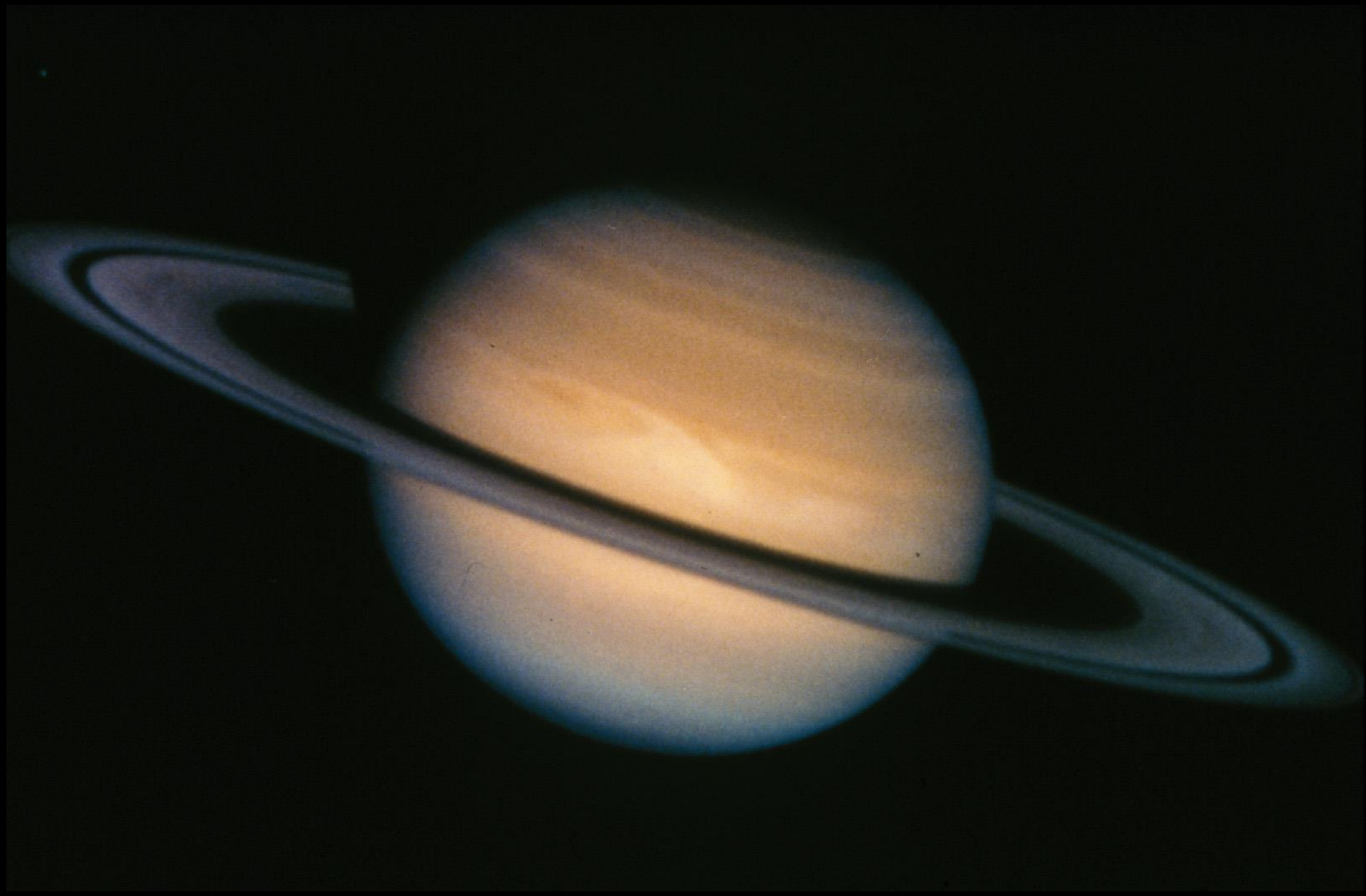


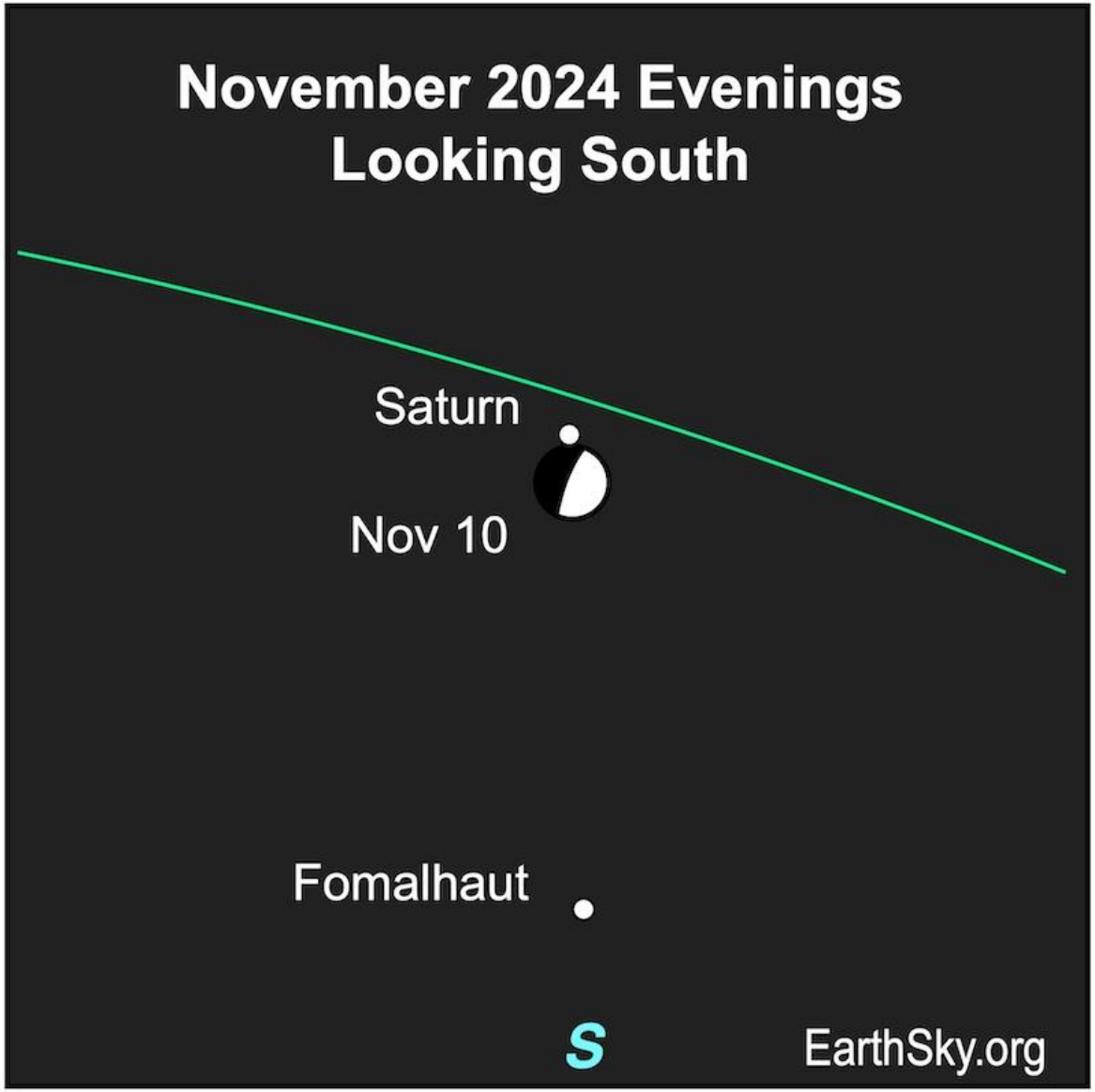
Possible model for giant planet interiors.



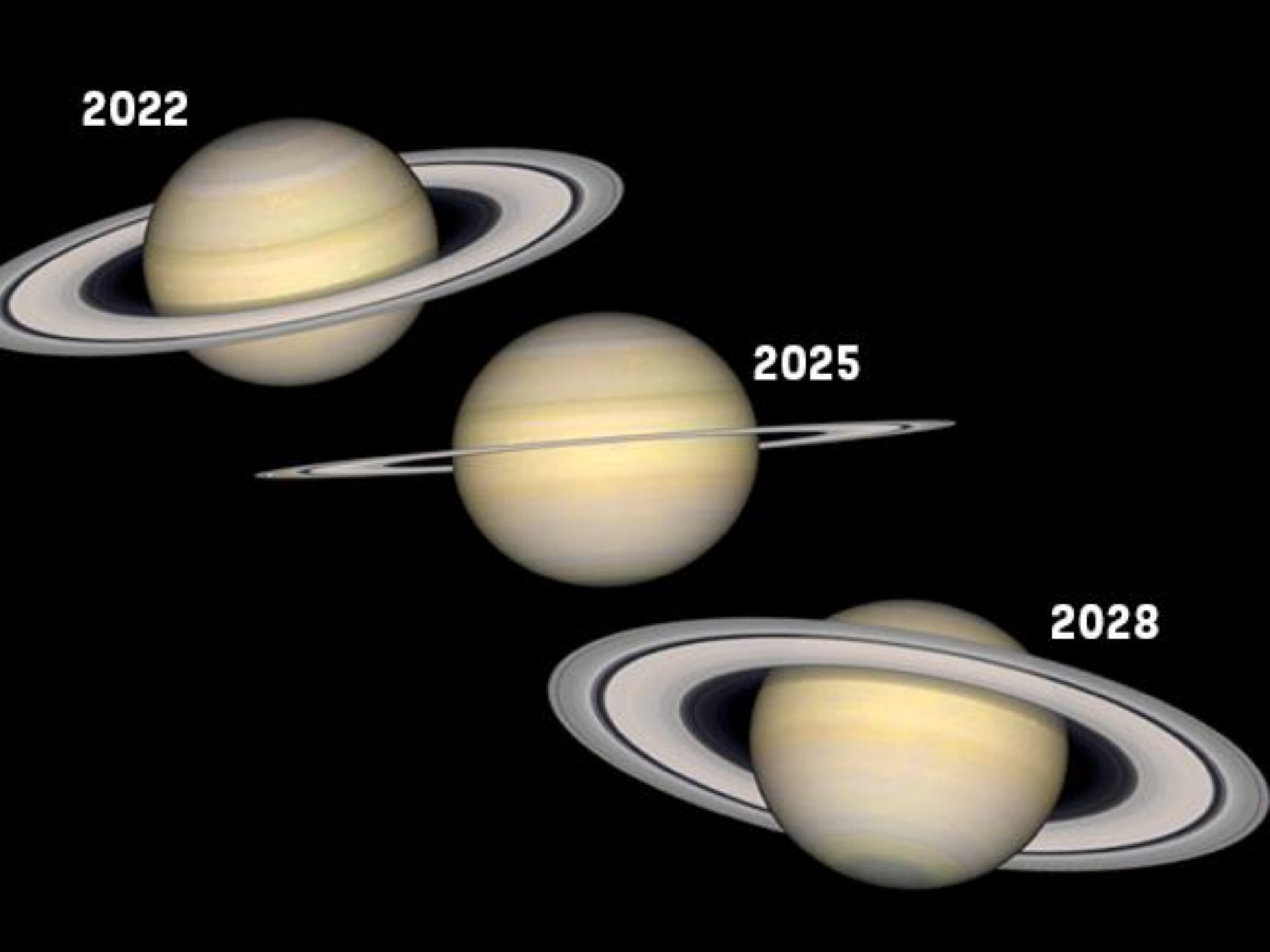
Jupiter at low magnification

Saturn

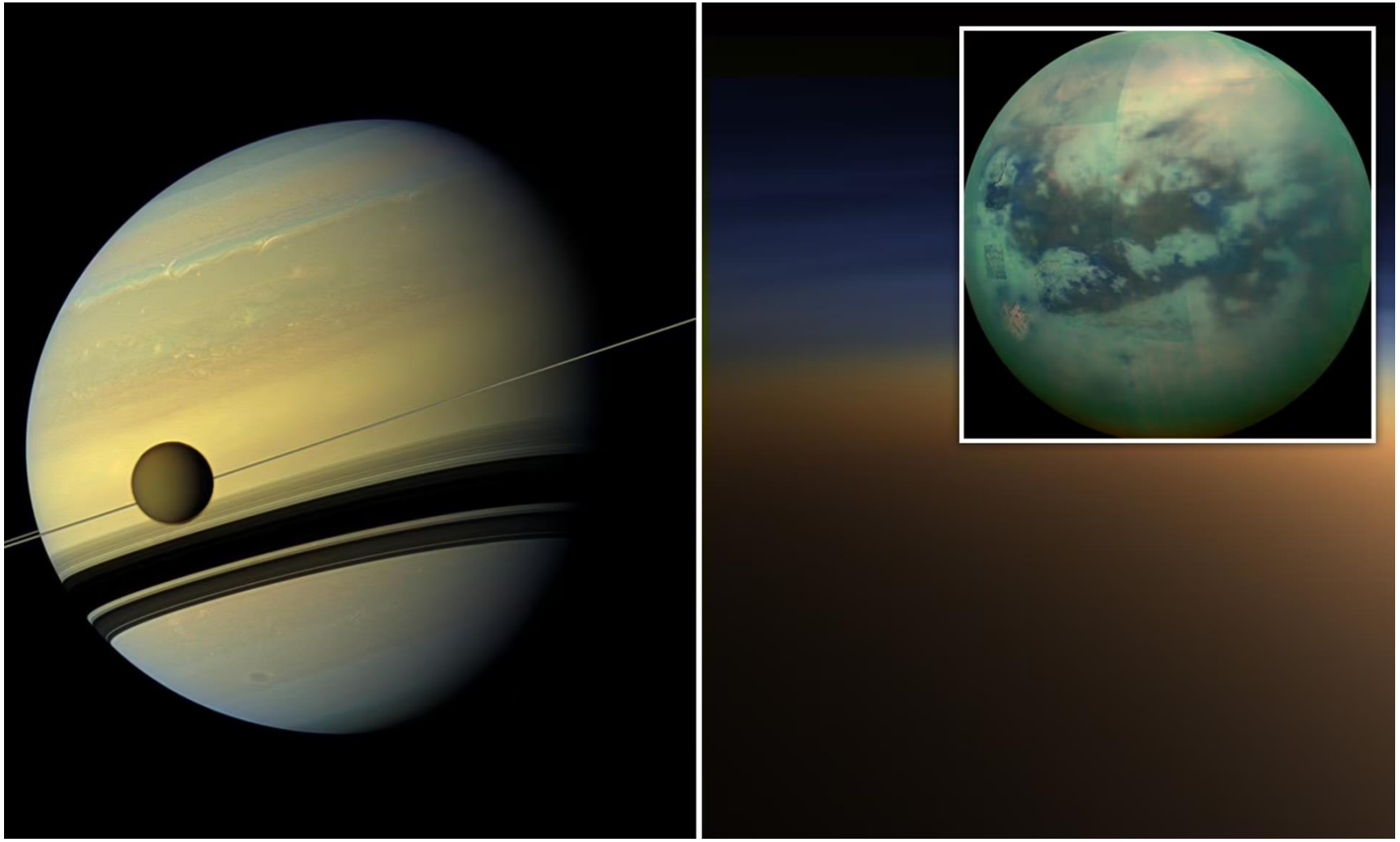


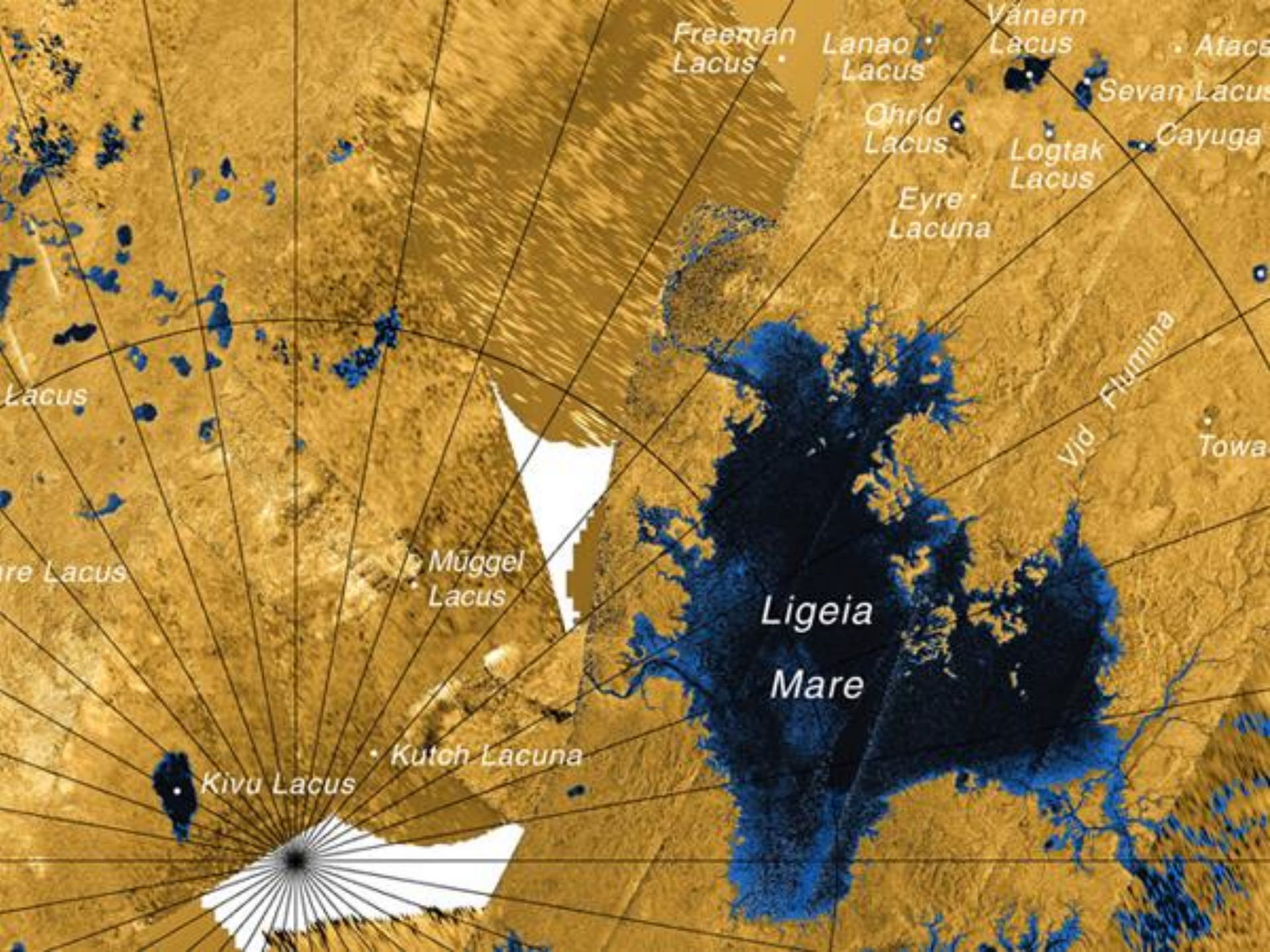

November 2024 Evenings
Looking South
Saturn
Nov 10
Fomalhaut
S
EarthSky.org

Saturn's Rings


2022
2025
2028

Saturn's Largest Moon – Titan




Freeman Lacus
Lanao Lacus
Vänern Lacus
Sevan Lacus
Ohrid Lacus
Cayuga
Logtak Lacus
Eyre Lacuna
Vid Flumina
Towa
Lacus
Müggel Lacus
Ligeia Mare
Kutch Lacuna
Kivu Lacus

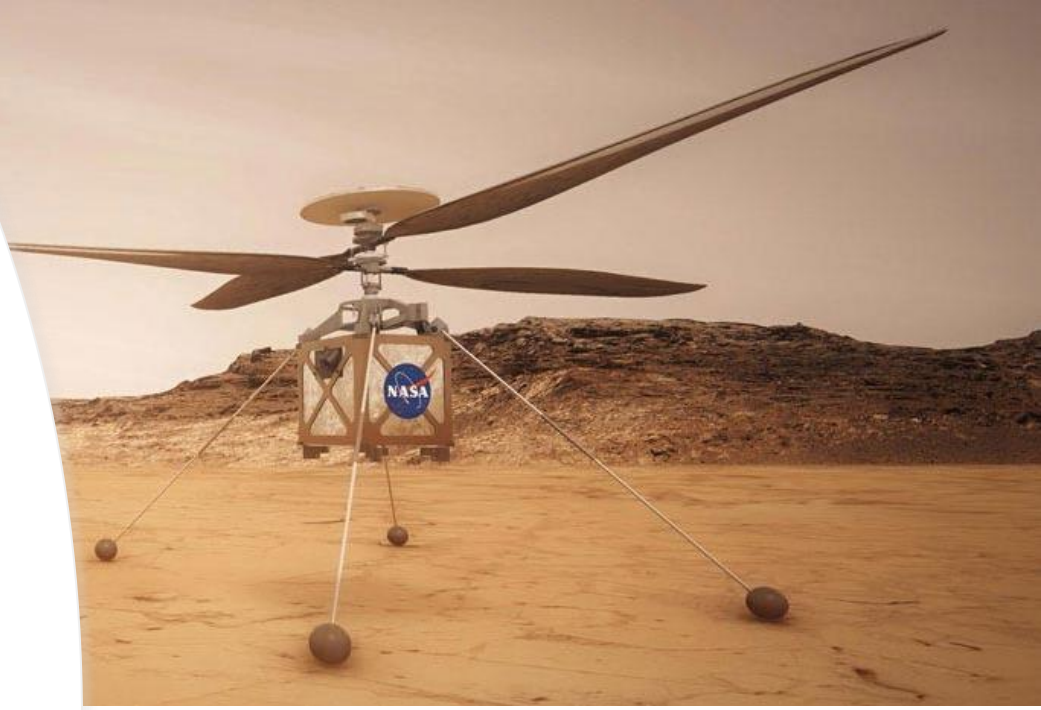
Lakeside Saturn sets on Titan? - not like this but fun to imagine...

New kinds of robotic spacecraft

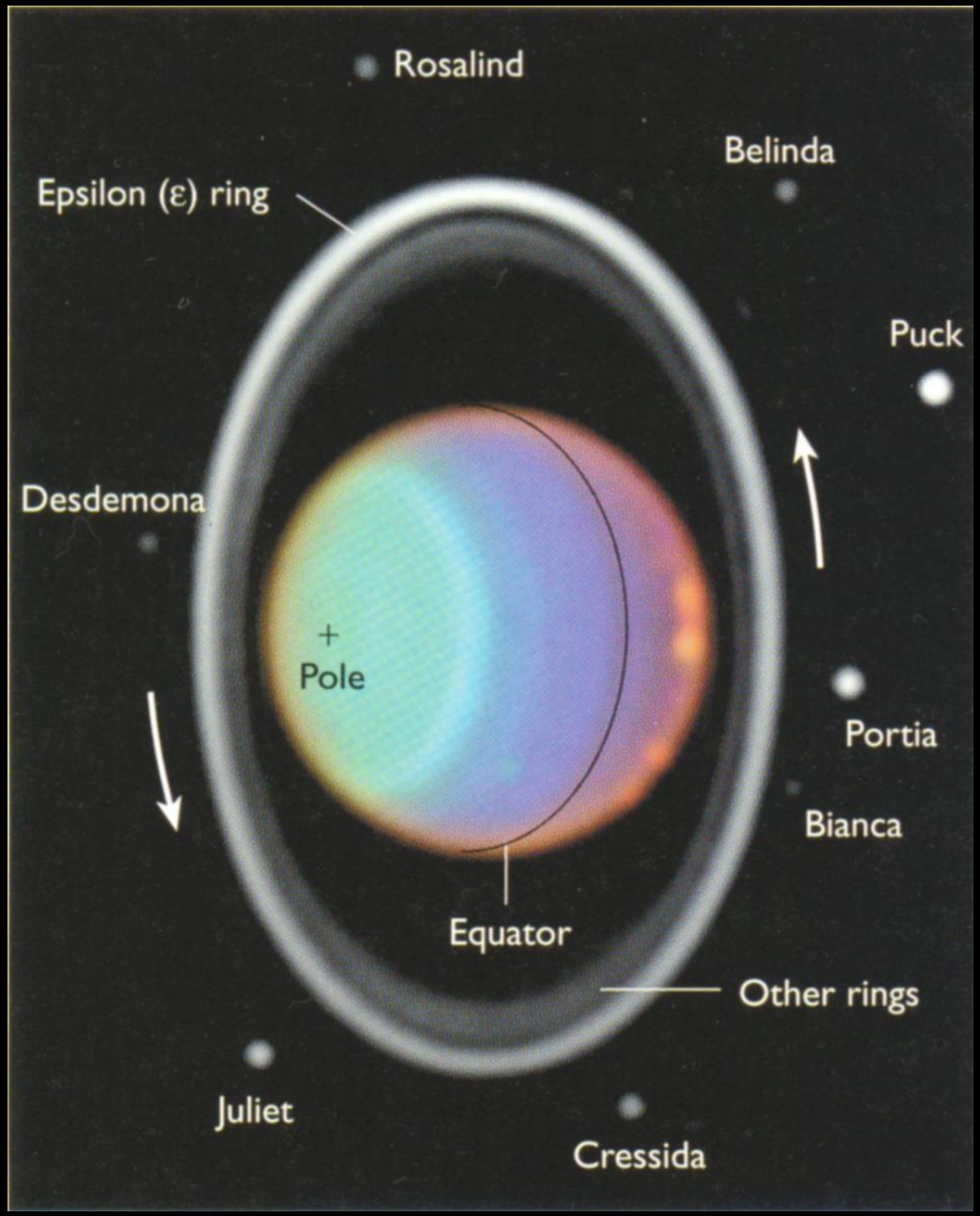
From Drones on Mars to

Proposed Drones on Titan

(Saturn'sLargest Moon)

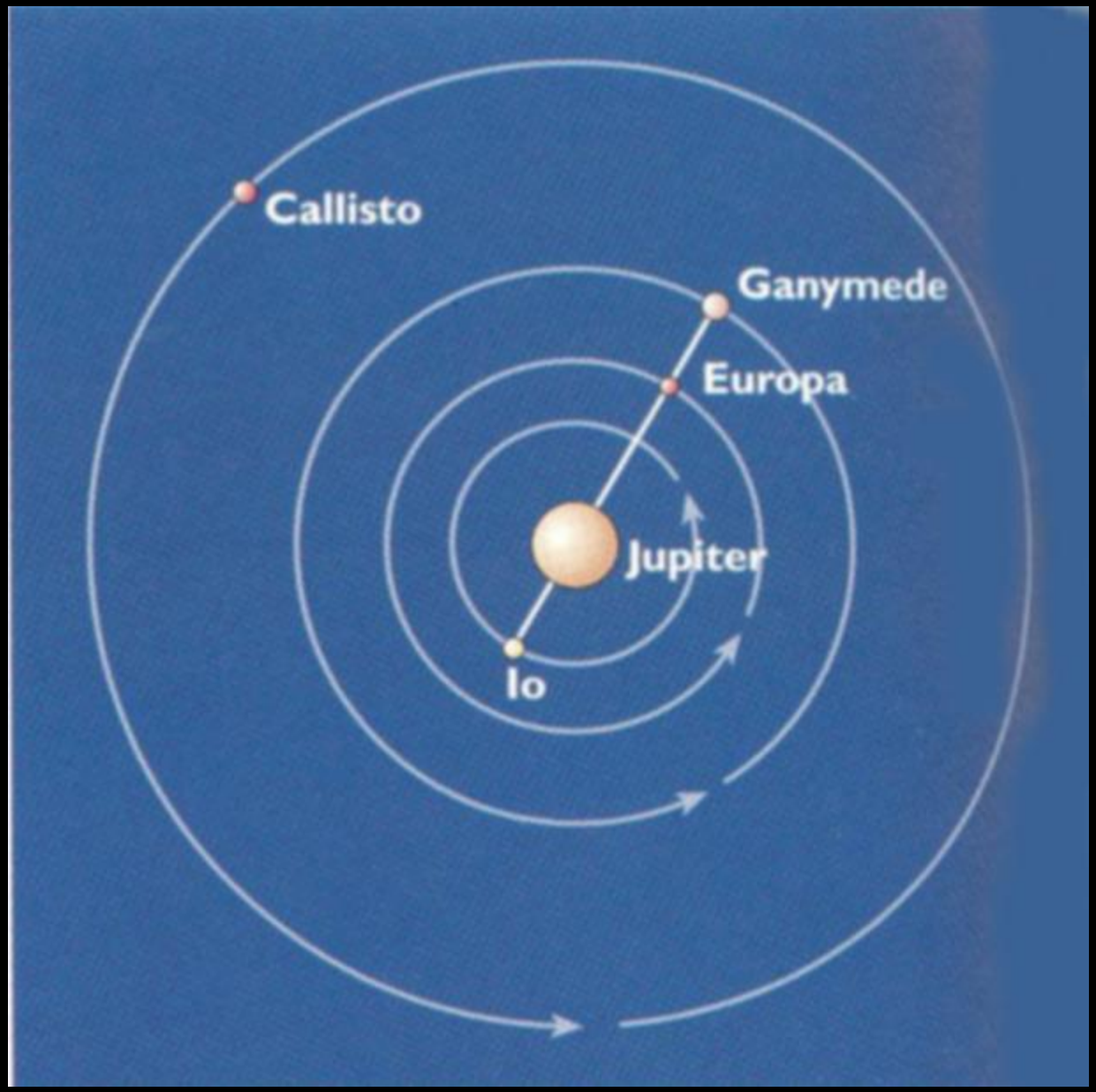


Uranus

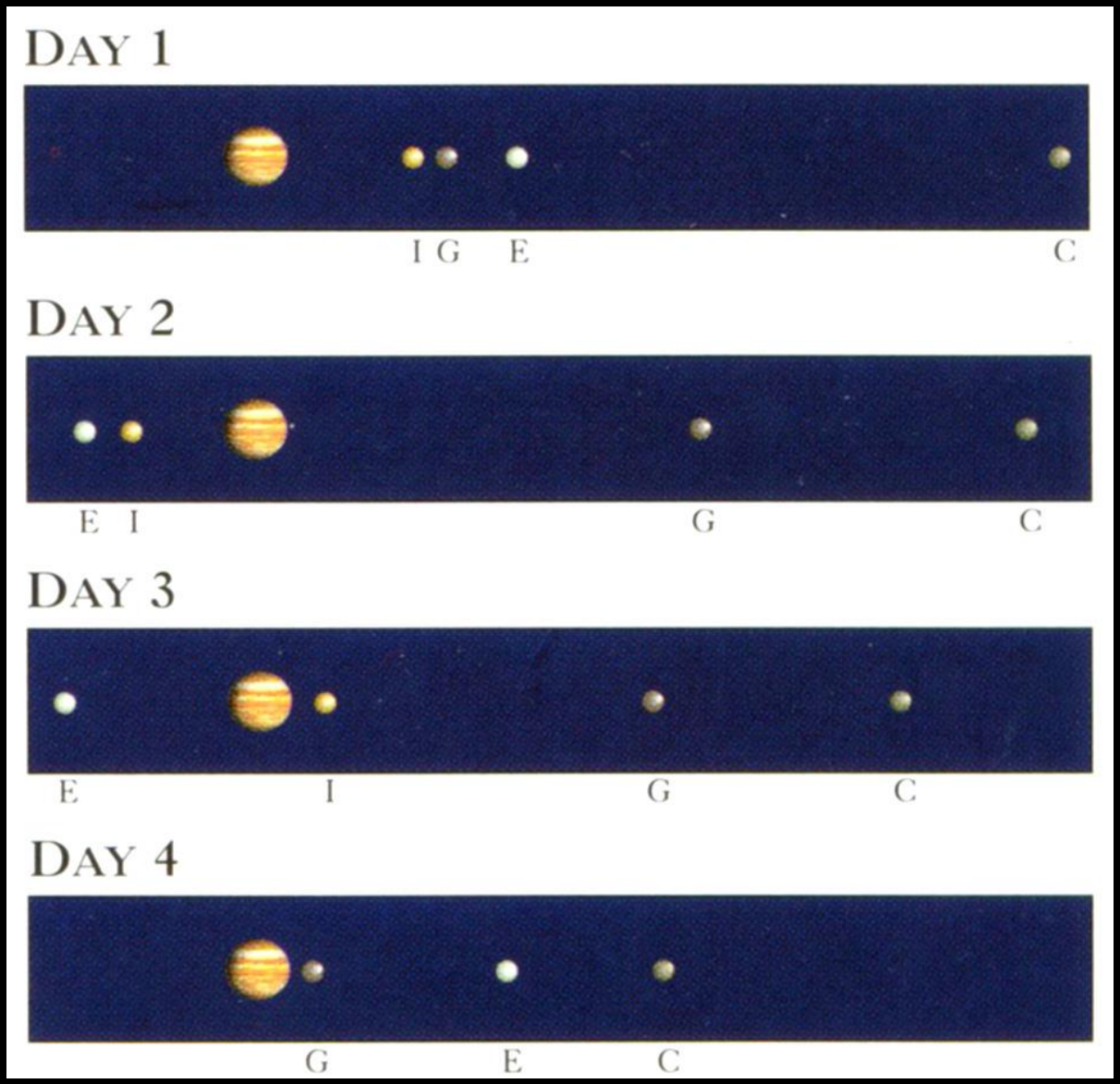

Rosalind
Belinda
Epsilon (ε) ring
Puck
Desdemona
Pole
Portia
Bianca
Equator
Other rings
Juliet
Cressida

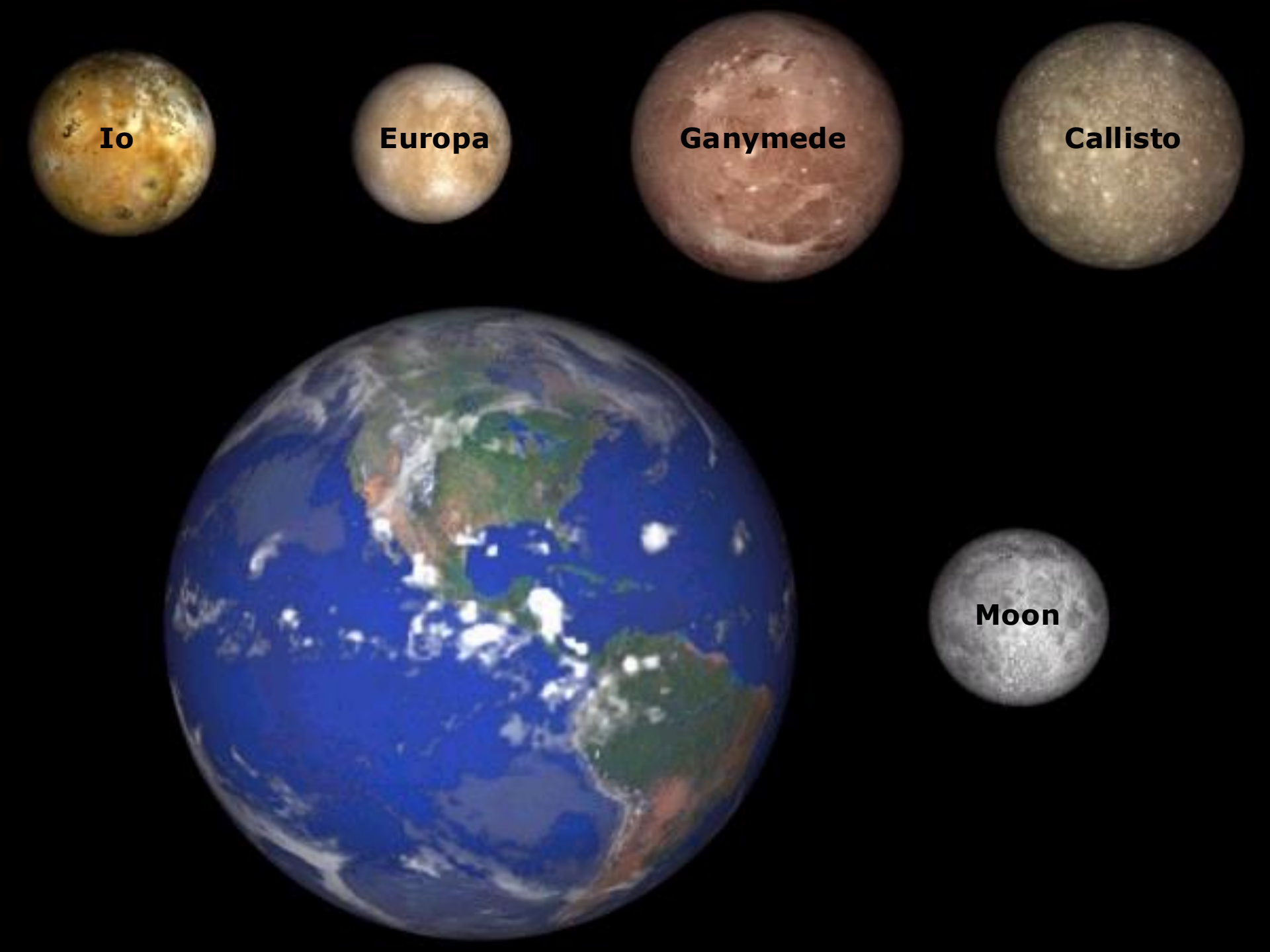
Neptune

Orbits of the Galileans

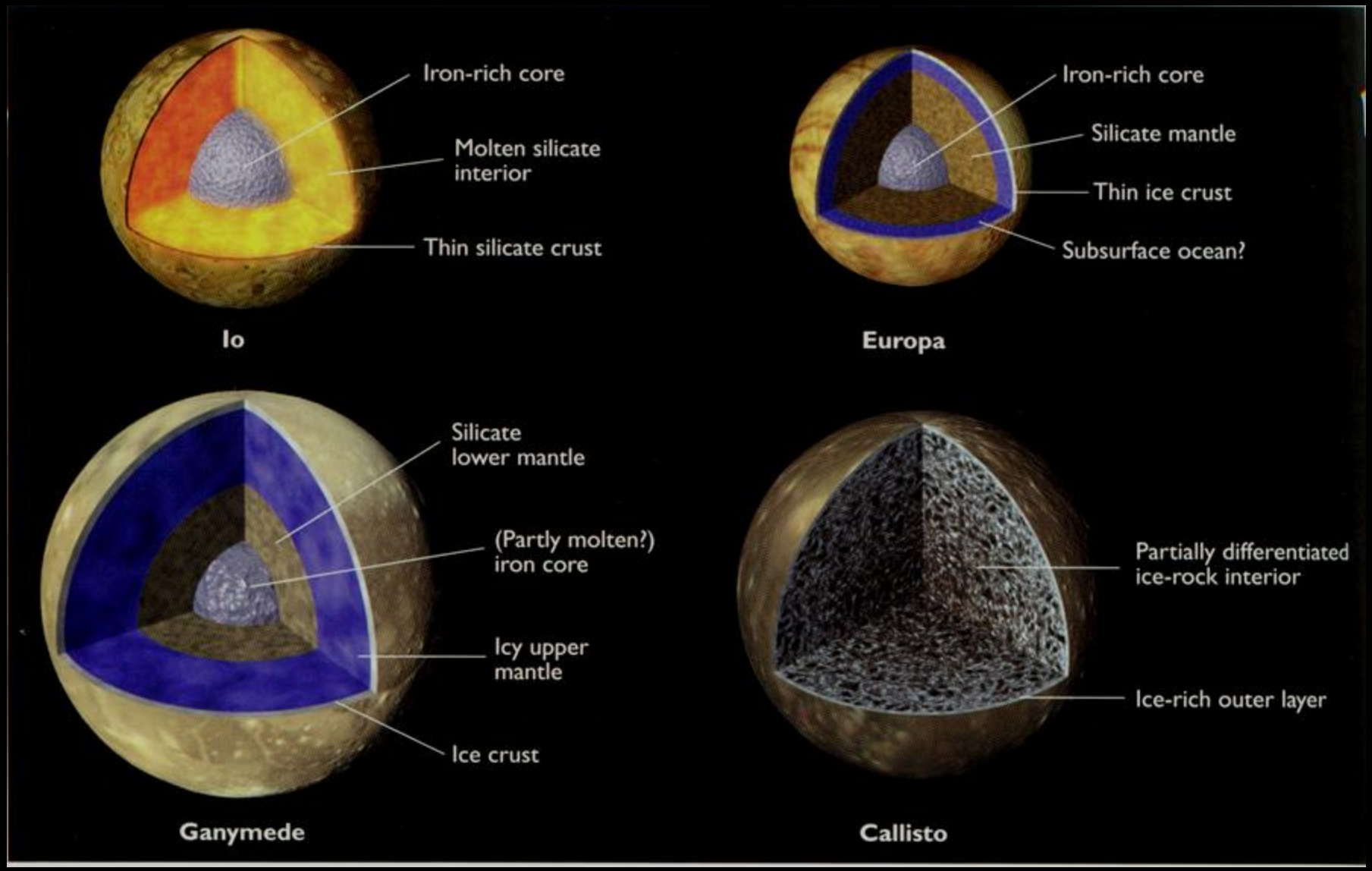


Observation of the Galileans

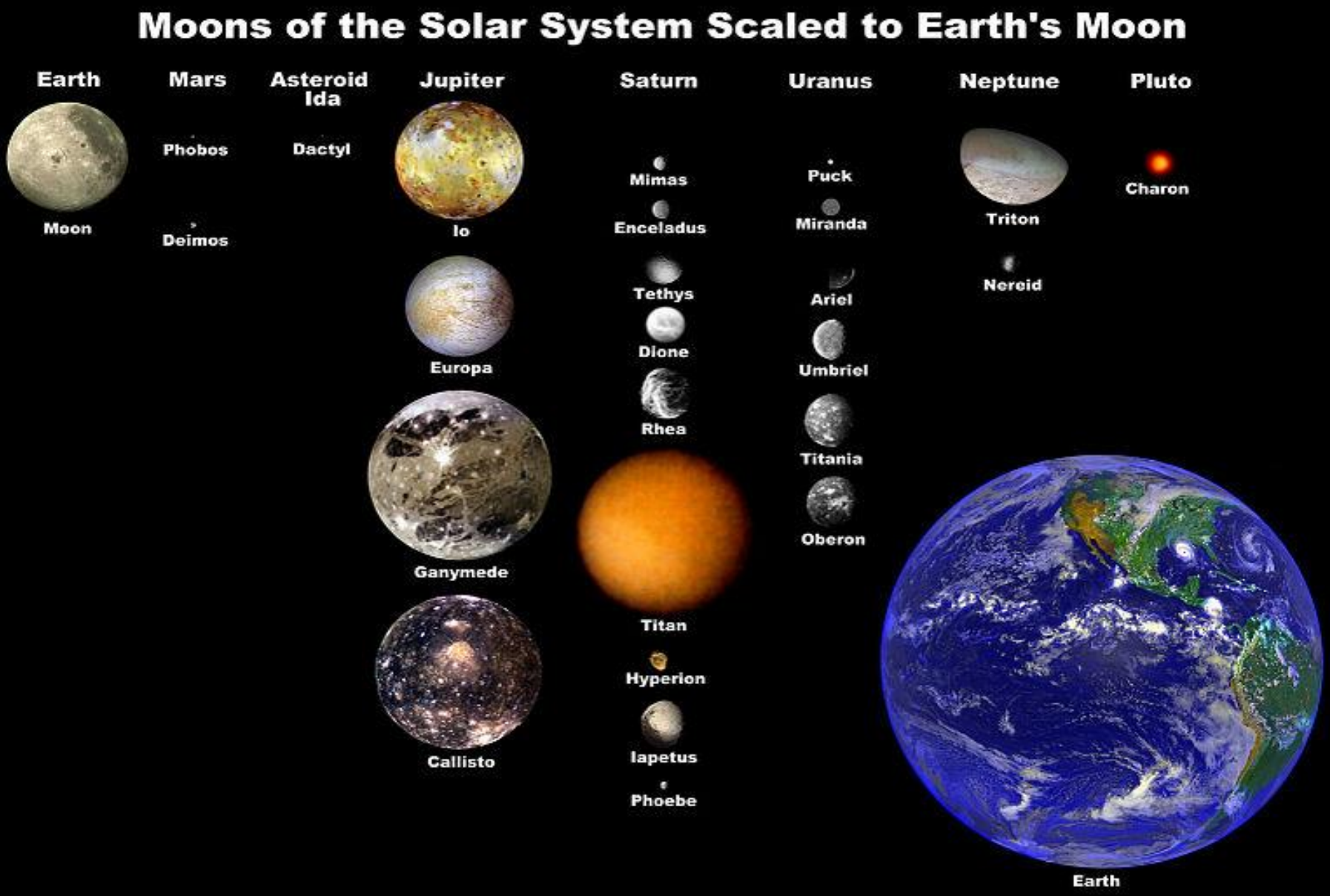



Io
Europa
Ganymede
Callisto
Moon

Interiors of the Galileans



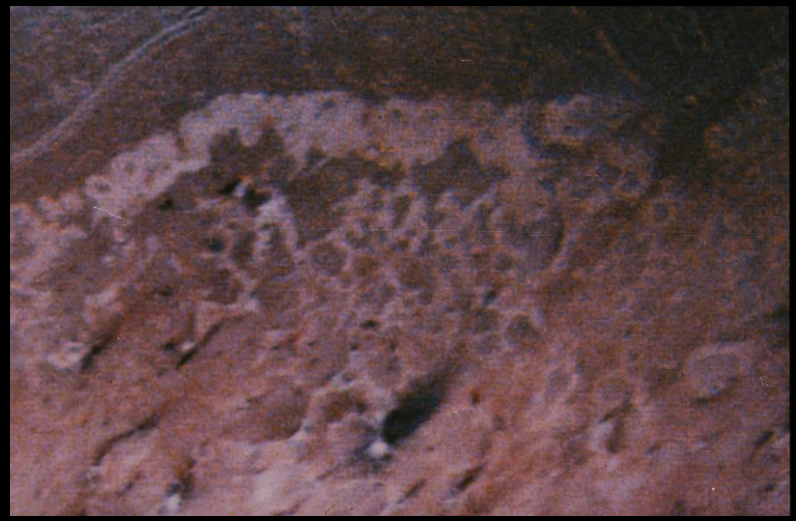
Moons - Hierarchv



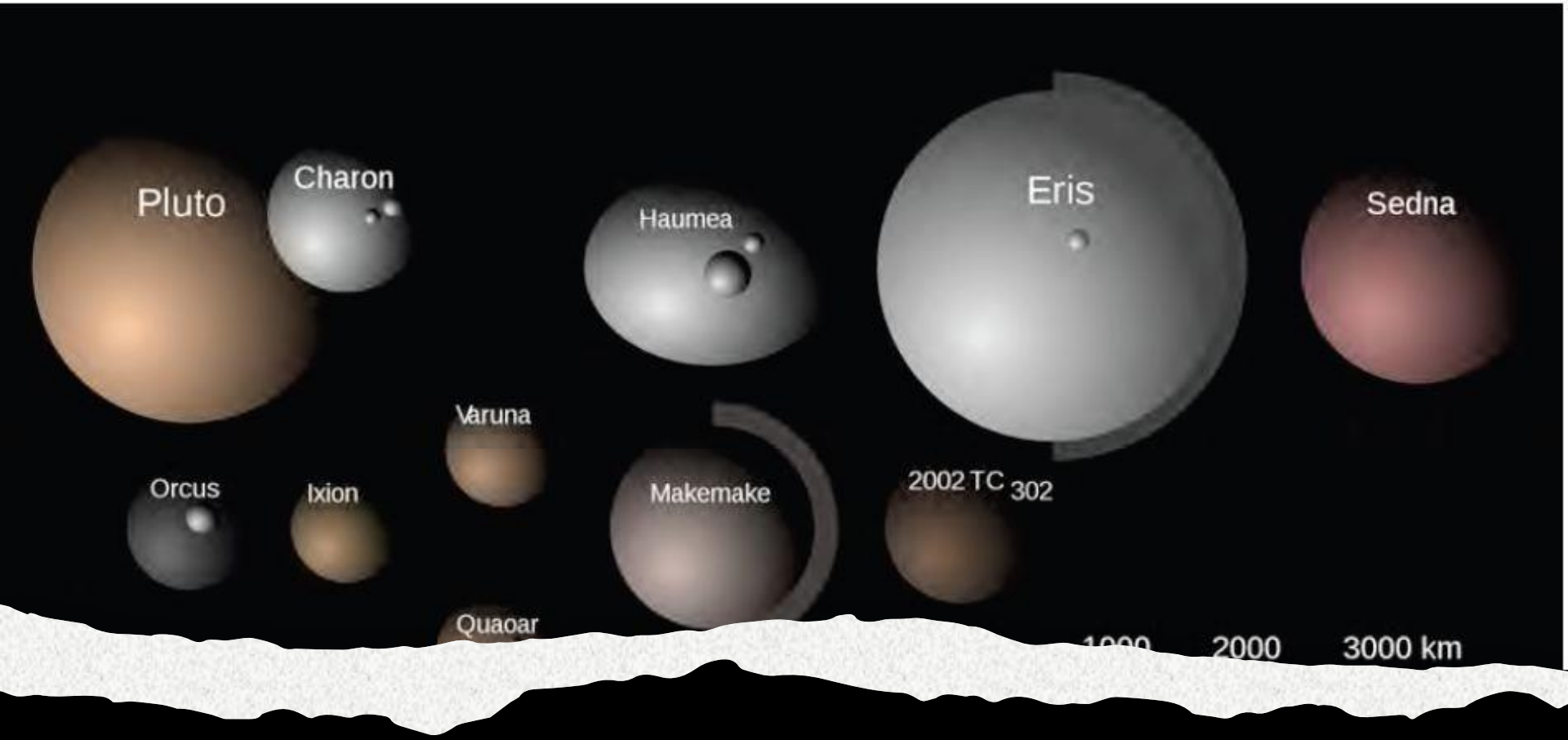
Triton – Captured Moon(most likely a dwarf planet from Kuiper Belt that came to close to Neptune)

Triton’s varied terrain

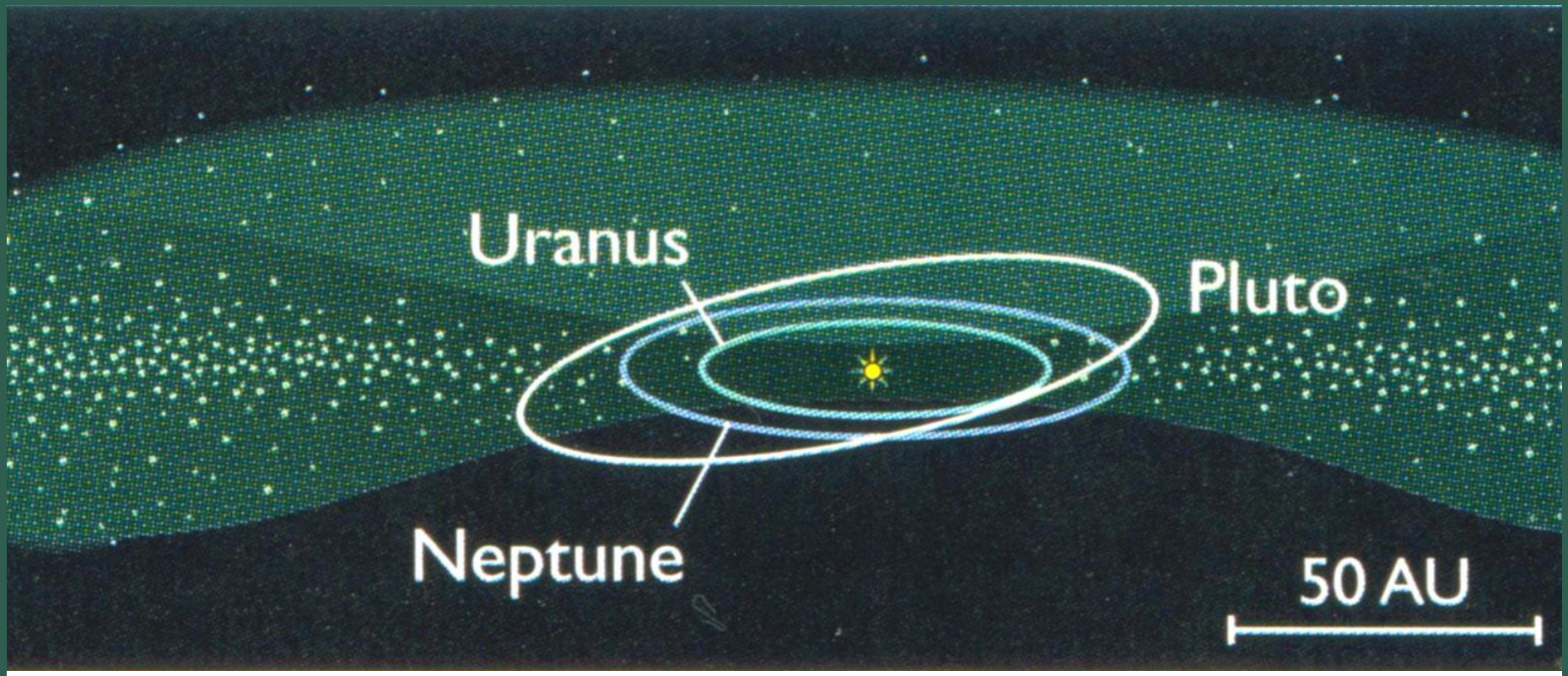
Cryo-Volcanism



Strange Planet Pluto?



Or Not so Strange Member of the "Dwarf Planets" or "Kuiper Belt Objects"

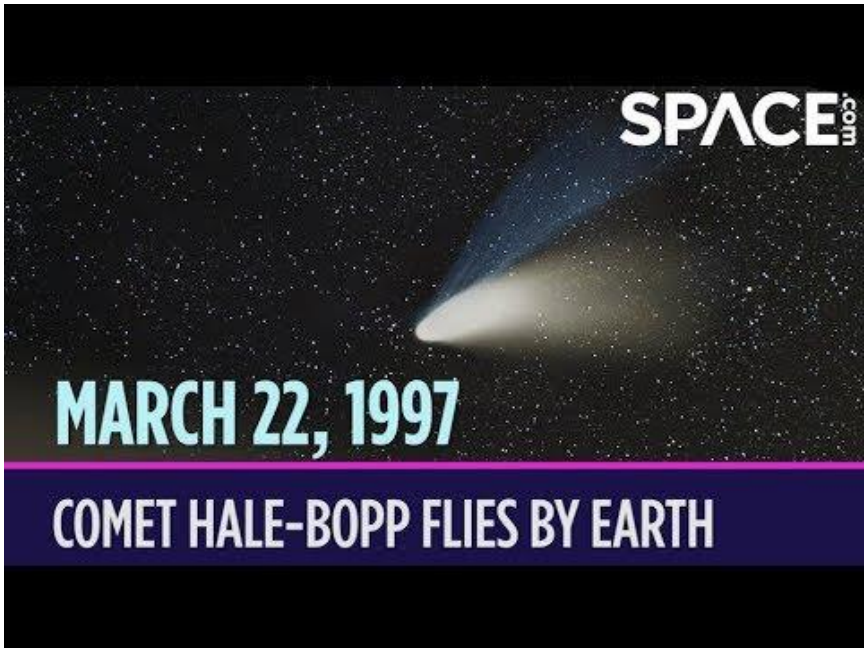


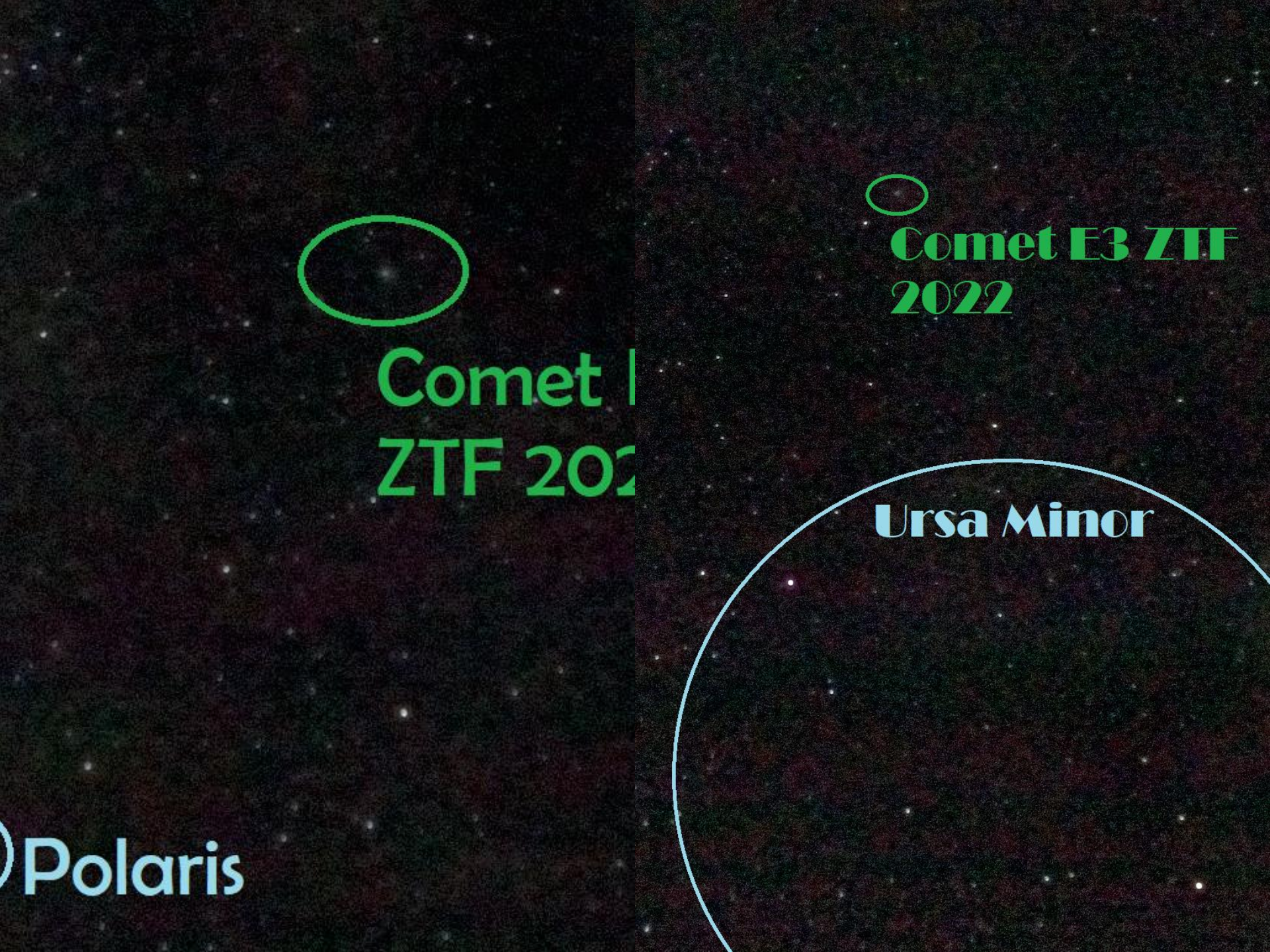
The Kuiper Belt

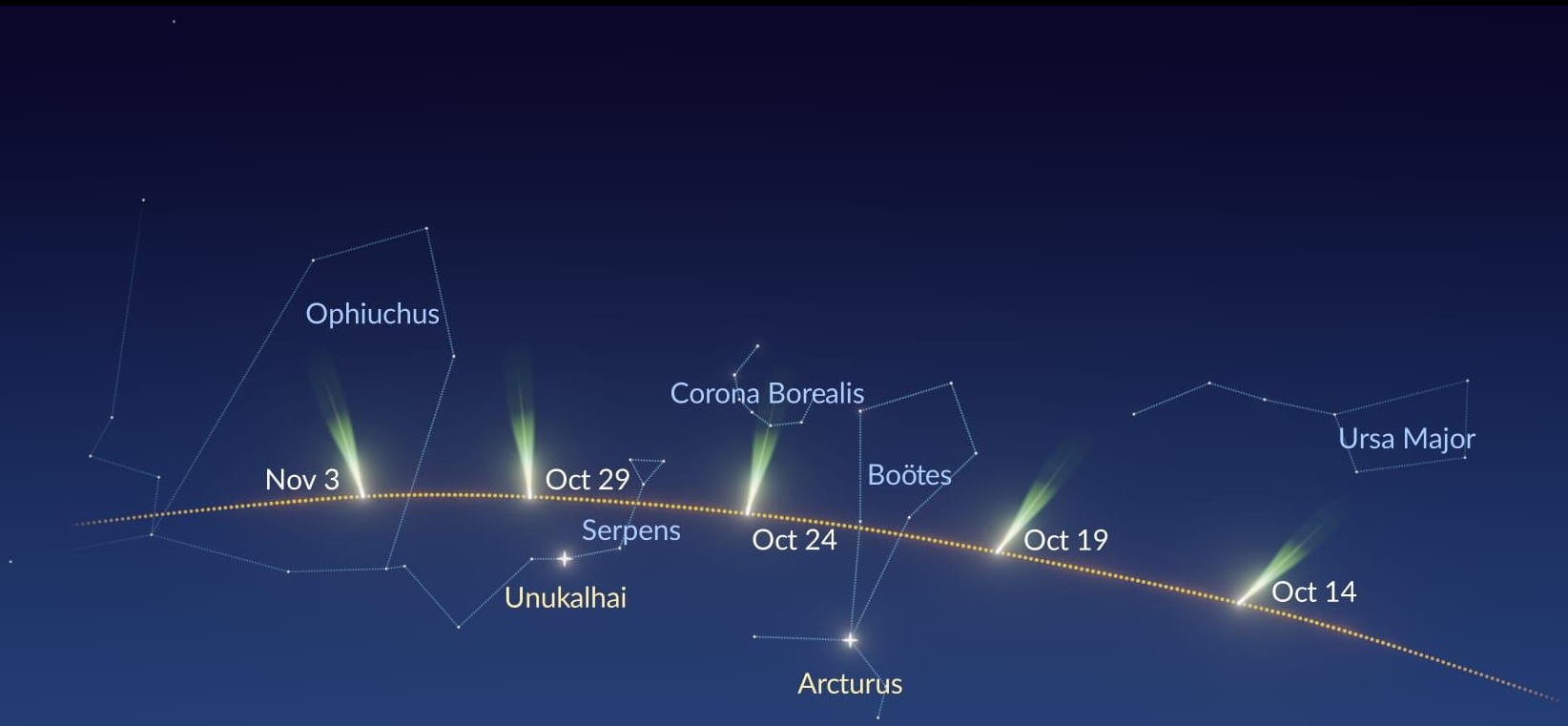
Comets

Comets up close

Comet Hale-Bopp and Comet NEOWISE



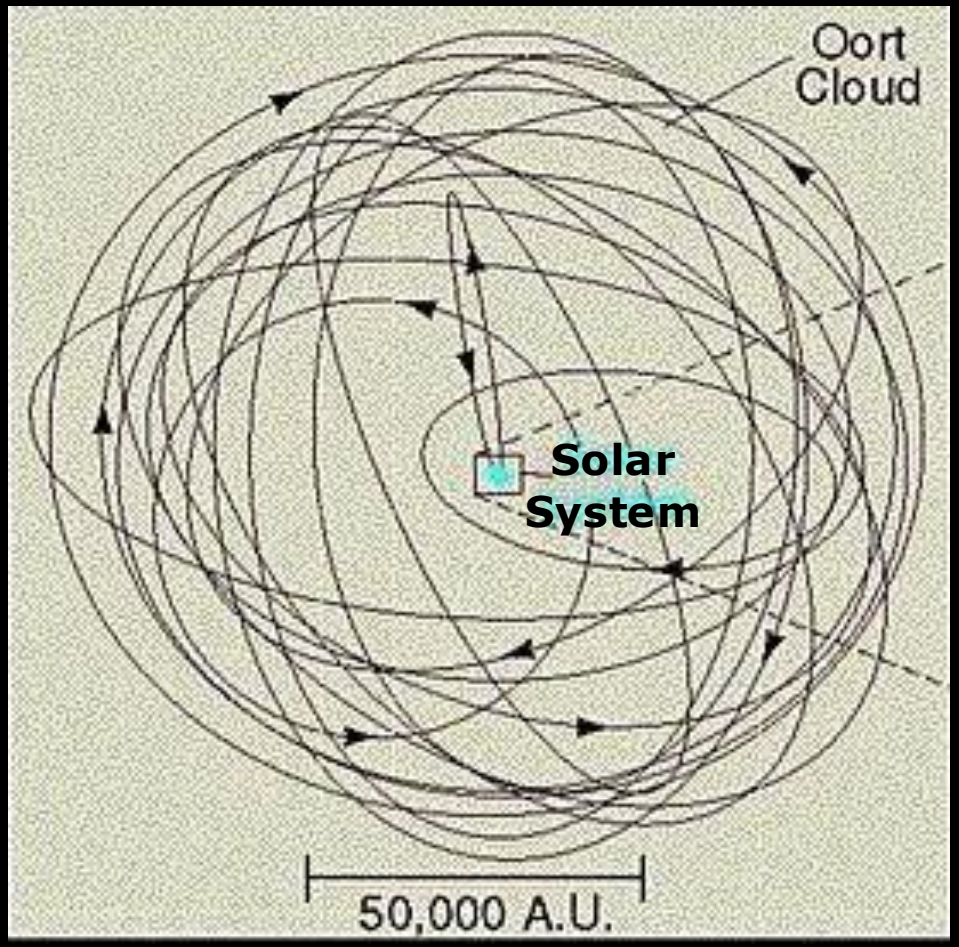

Comet E3 ZTF
2022
Ursa Minor
Polaris

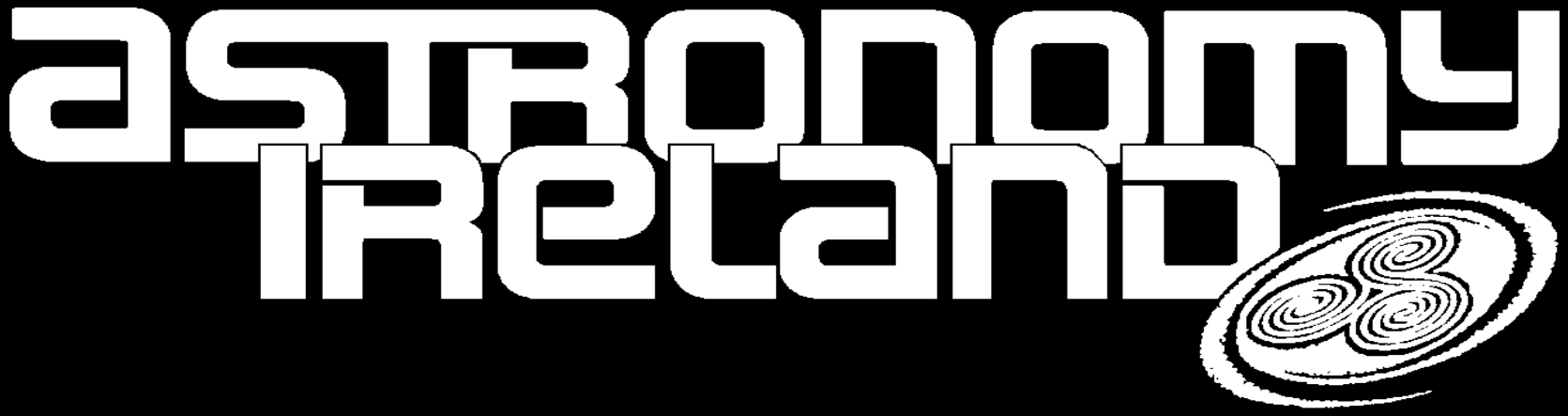


C/2025 A6 (Lemmon)

The best comet of fall 2025

The Oort Cloud





Useful websites

www.astronomy.ie/handouts

Thank You