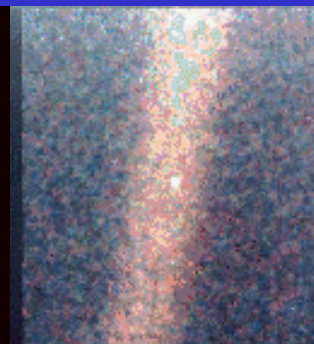
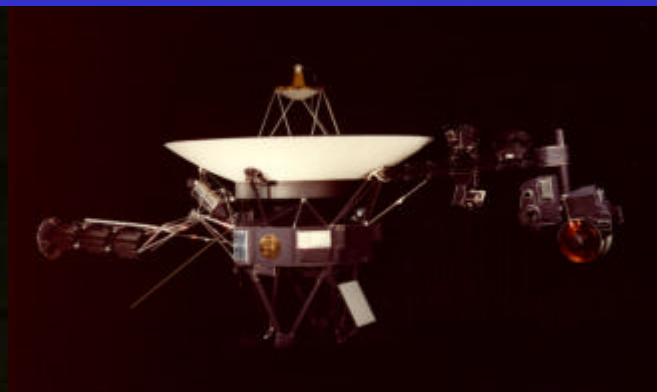
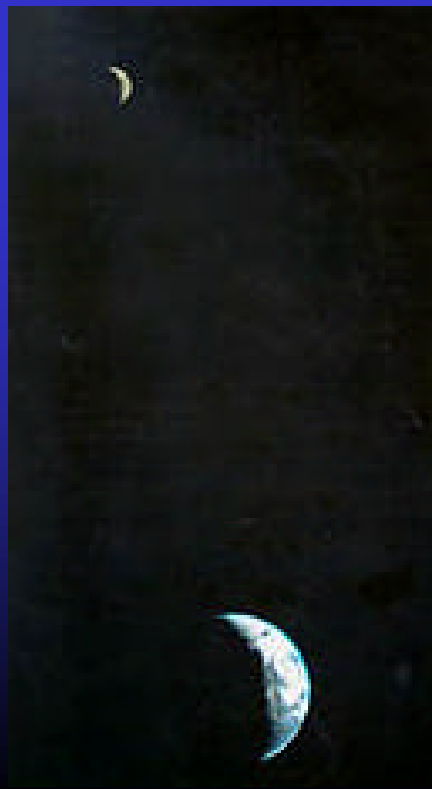


The Voyager Odyssey

375th Birthday of Christiaan Huygens

Titan: From Discovery to Encounter

ESTEC – Noordwijk – April, 13, 2004



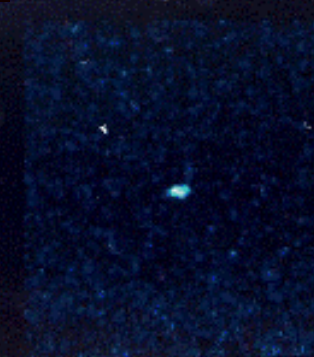
EARTH



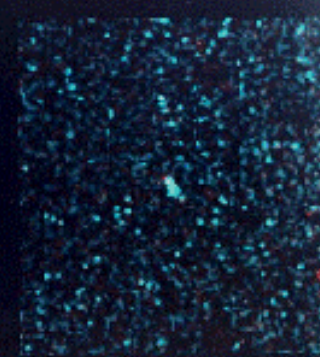
JUPITER



SATURN

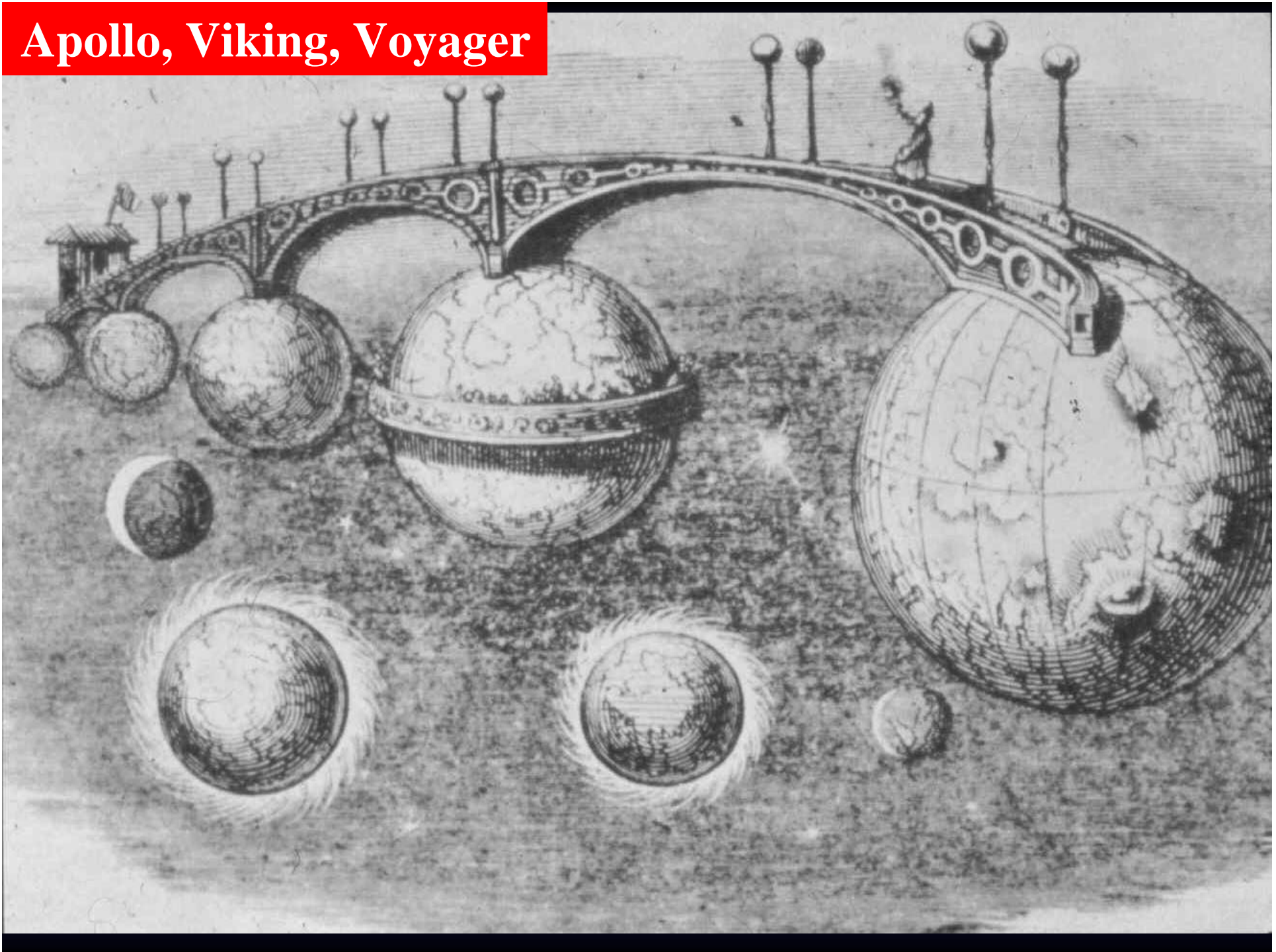


URANUS



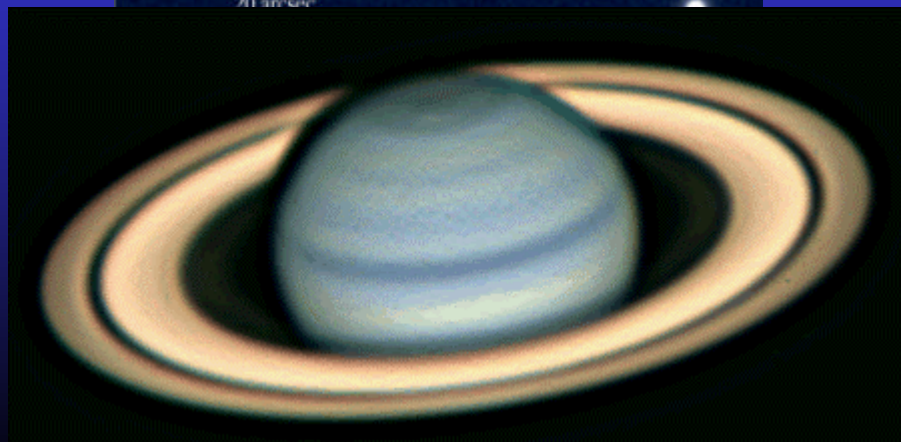
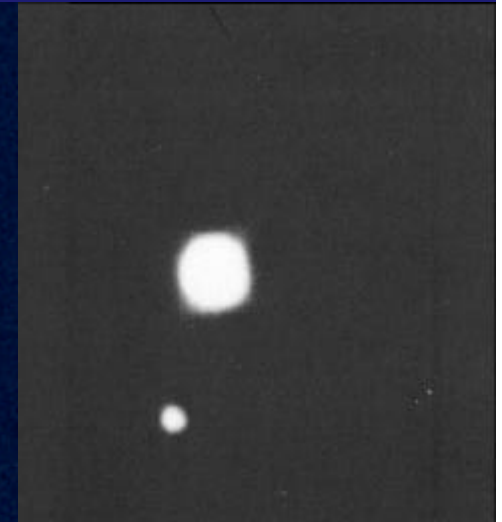
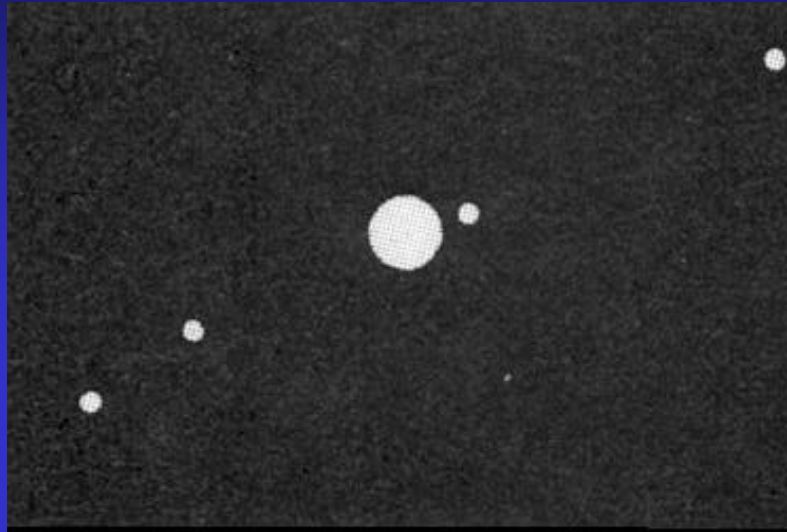
NEPTUNE

Apollo, Viking, Voyager





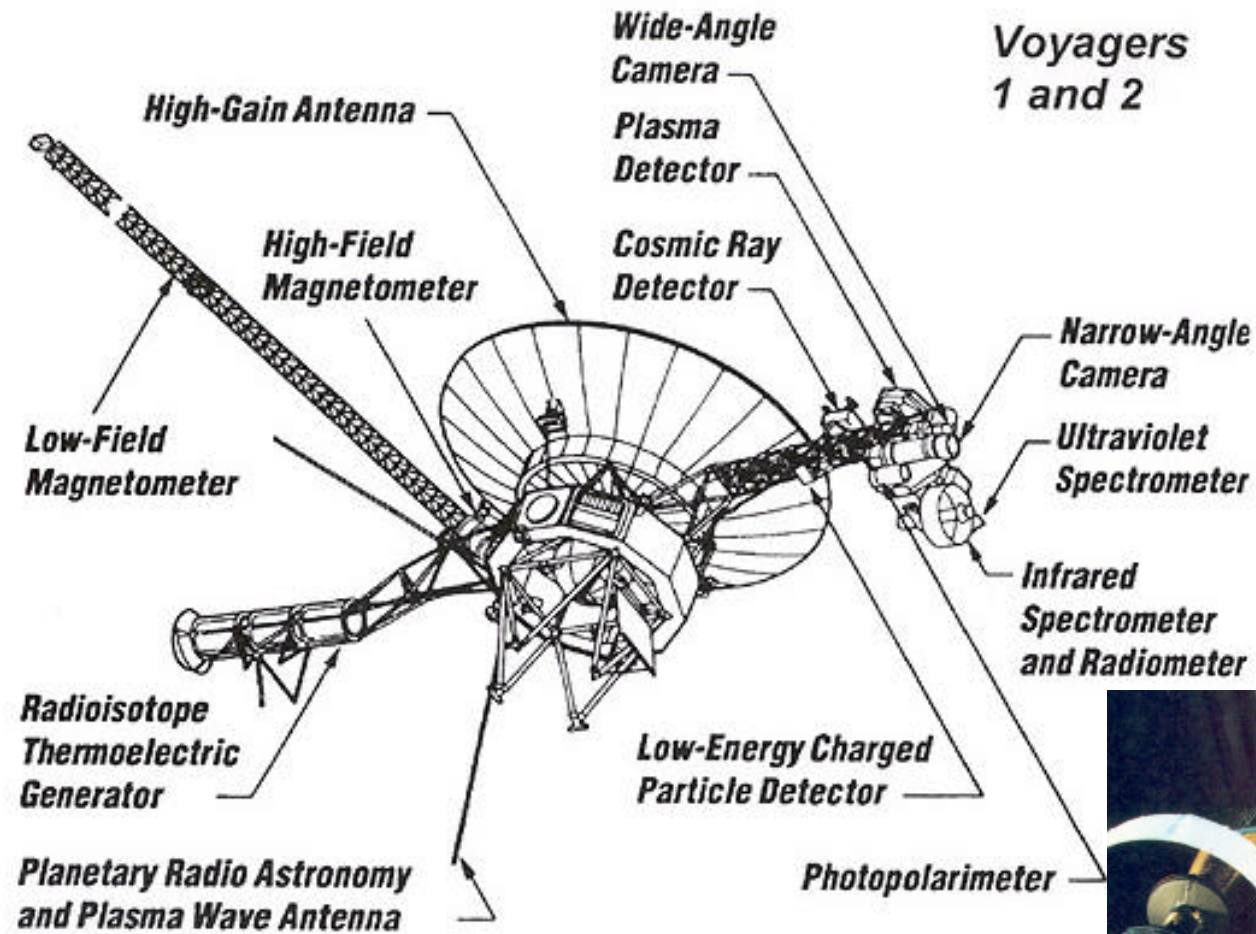
Before Voyager



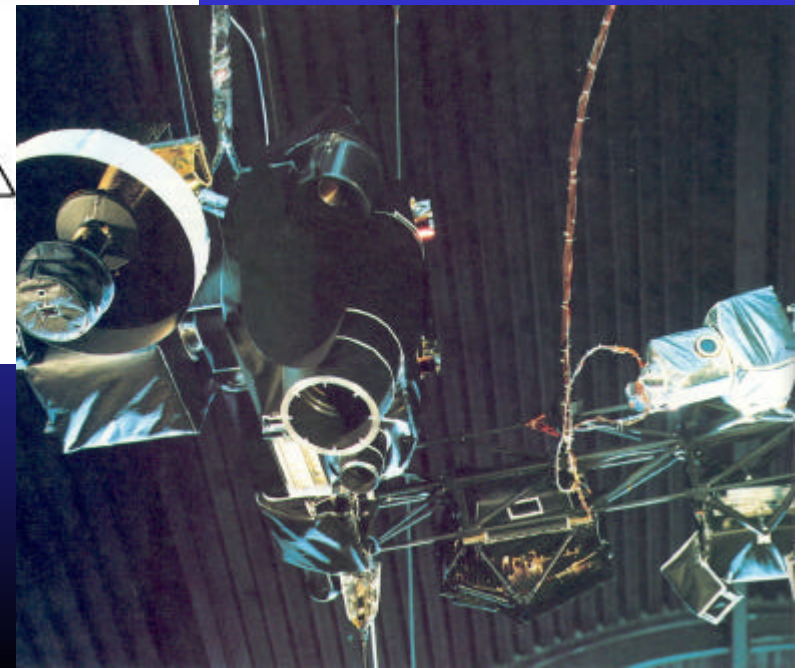
Outer Planets Grand Tour (1969)

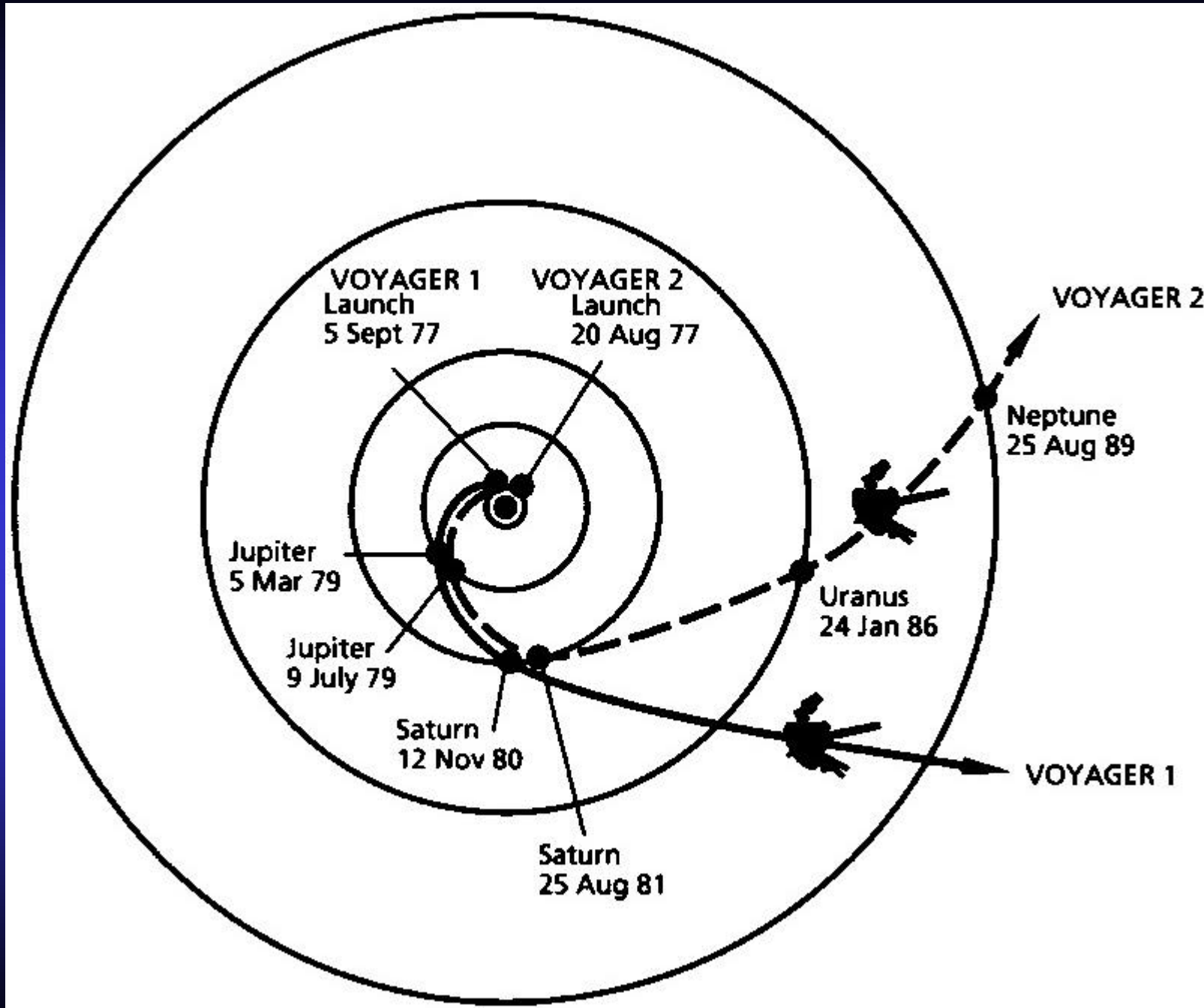
- Rare geometric arrangement of outer planets (~ 175 years)
- « Gravity assist » technique: Neptune: 30 ↘ 12 years
- Dual launches: Jupiter, Saturn, Pluto (1976 - 77)
- Dual launches: Jupiter, Uranus, Neptune (1979)
- ~ 750 M \$
- 1972: budget ↘ ☹
- ☺ Mariner Jupiter Saturn ~ 250 M \$

**DSN ? 23 w
transmitting power**

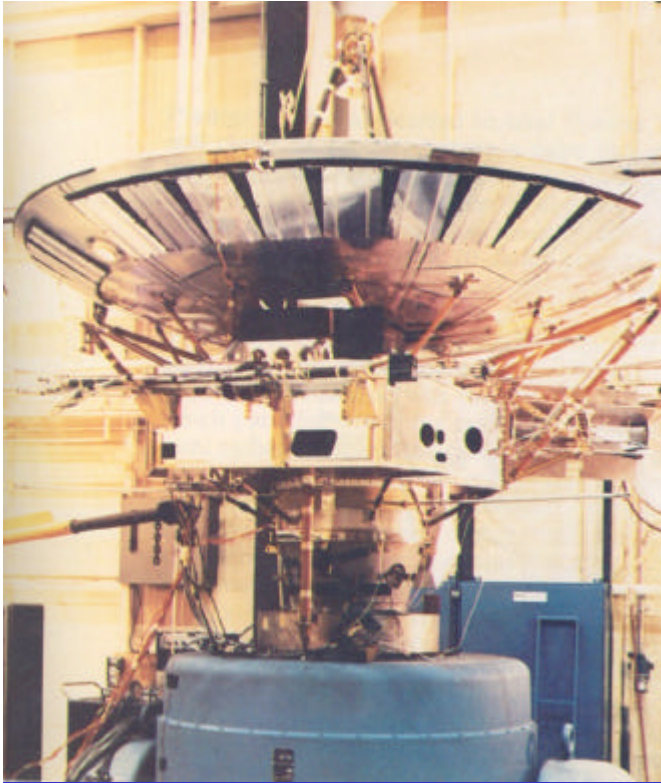


815 kg







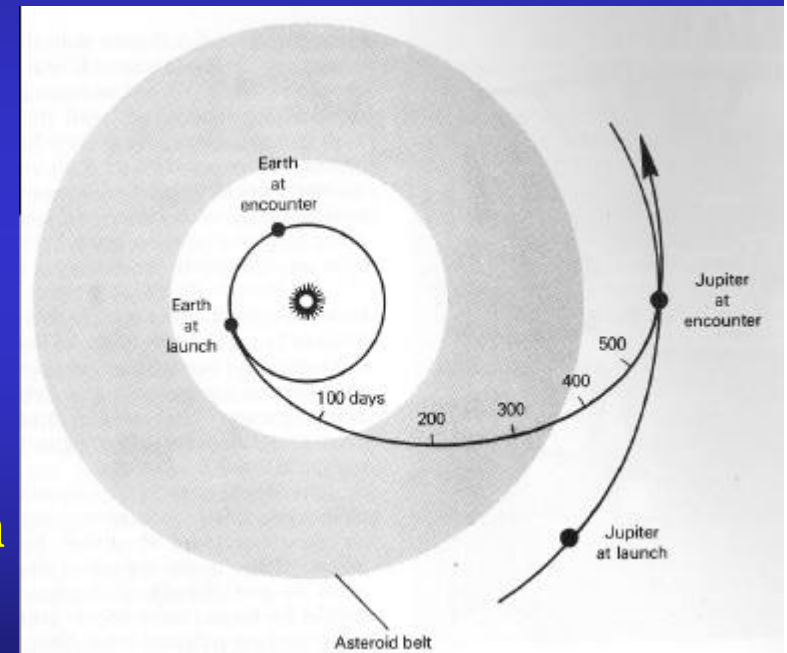


First step to the Grand Tour:

- Pioneer flyby of Jupiter
- 10 times farther Venus or Mars
- Economy and reliability
- Spinning design

2 potentially lethal hazards:

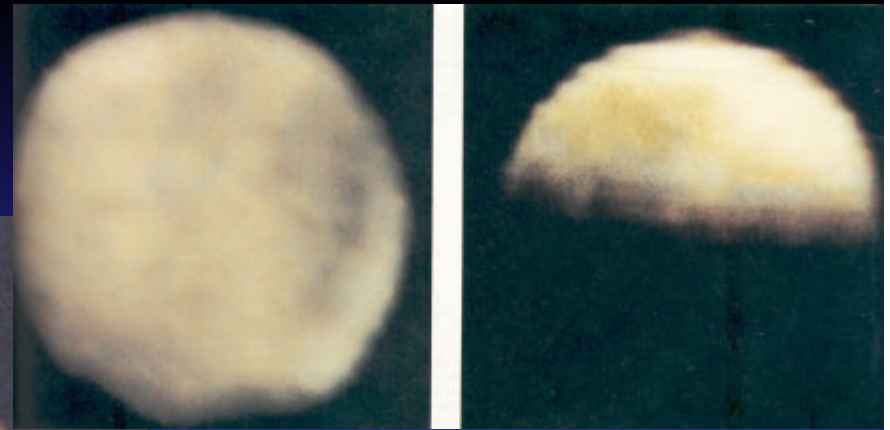
- Asteroid belt: large amounts of debris?
- Jovian magnetosphere: electronic brain damaged by energetic charged particles?



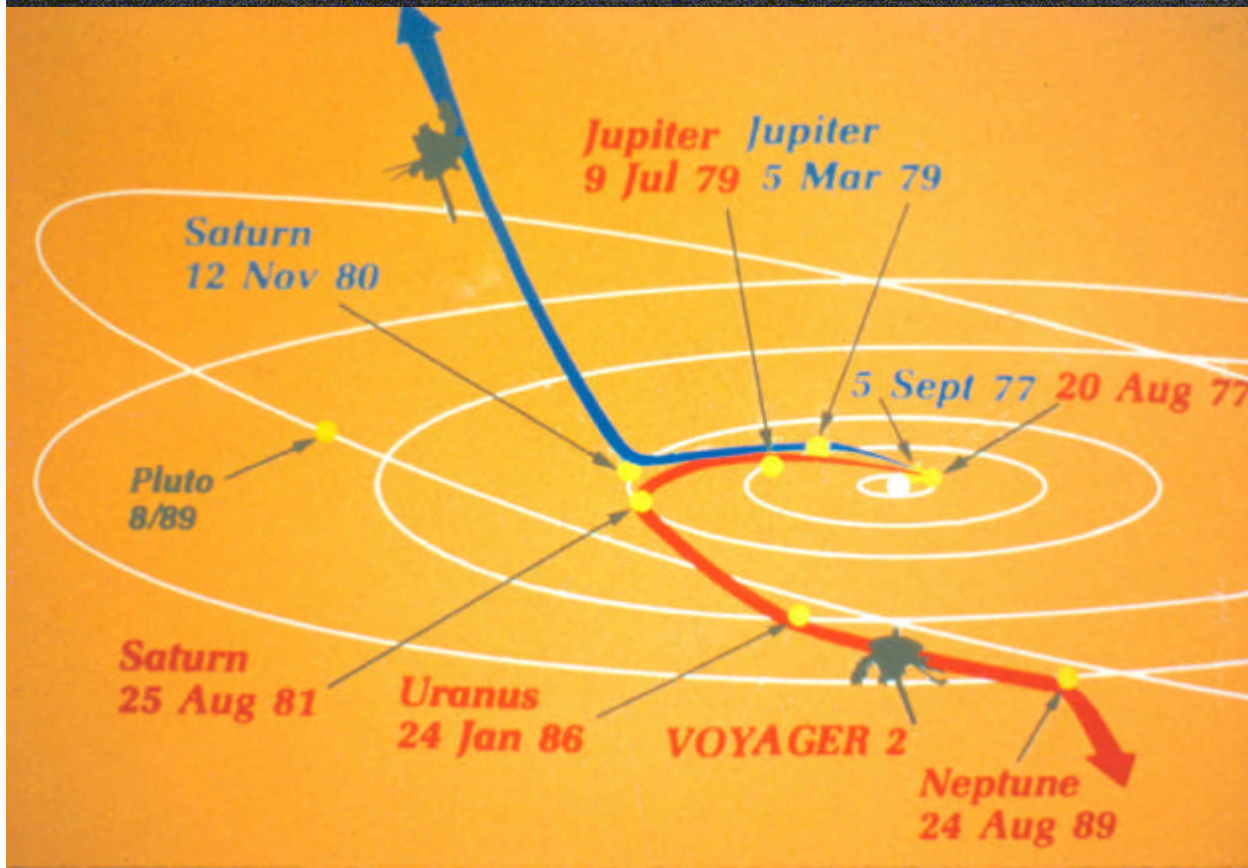
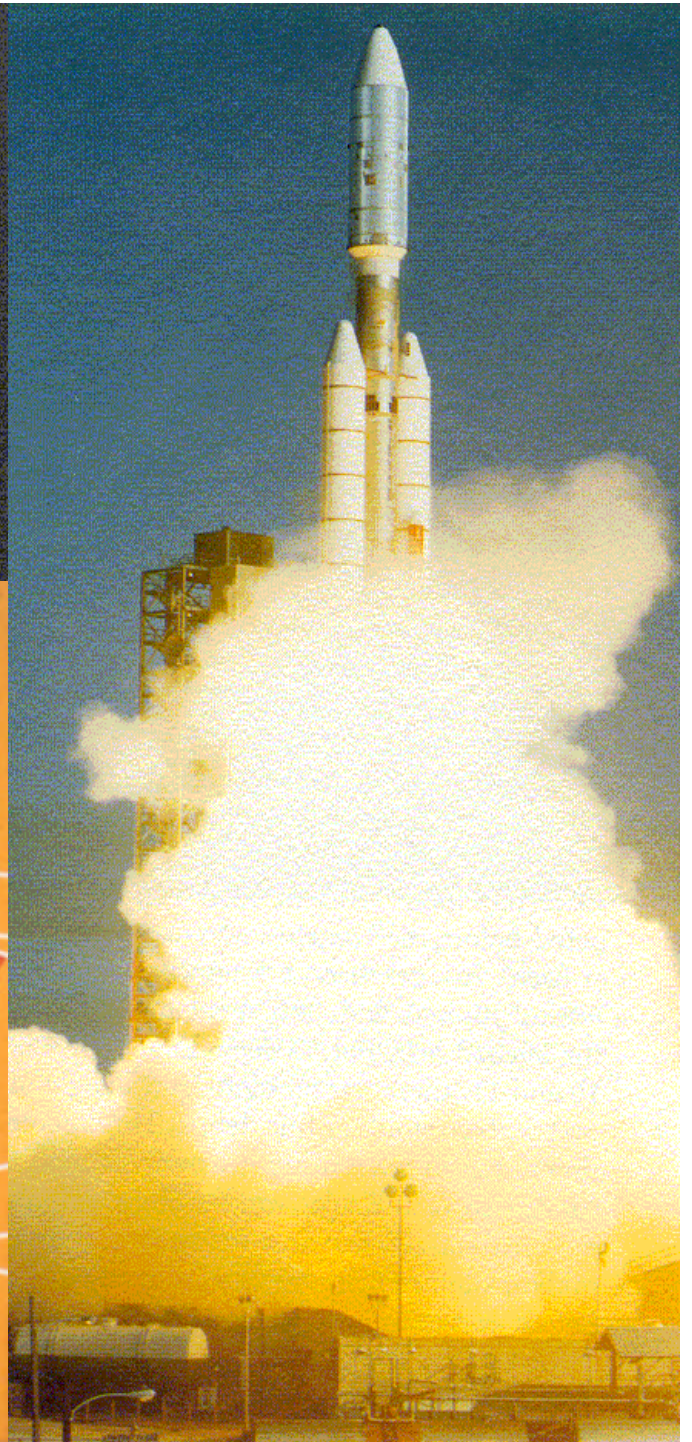
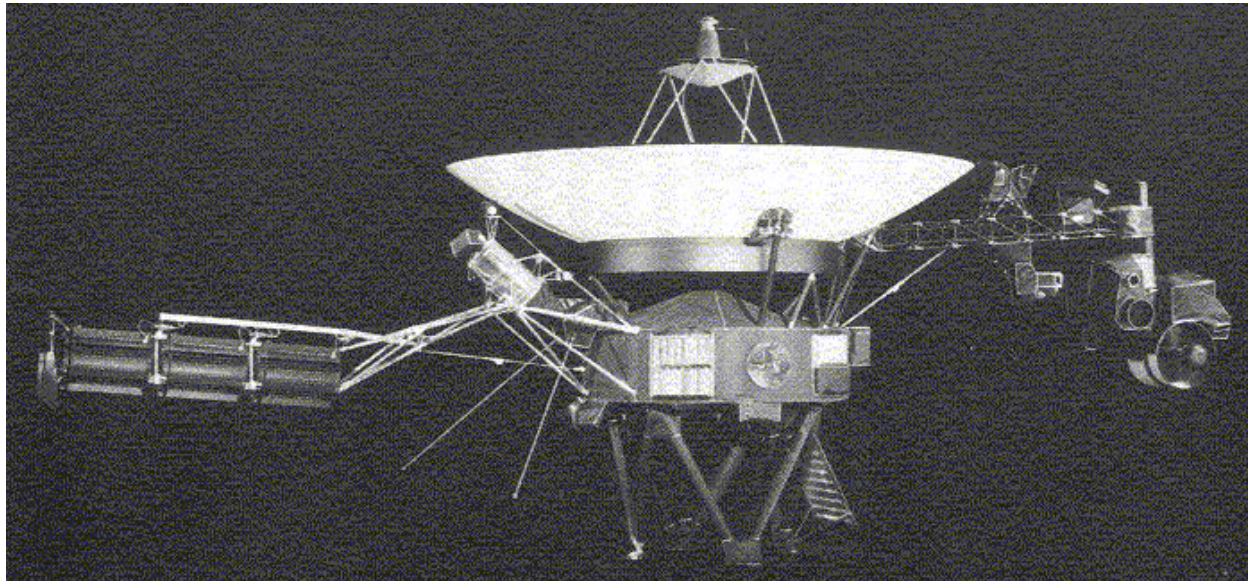
March 2, 1972: Pioneer 10 ? December 3, 1973: 1.3 10^5 km Jupiter

Pioneer 11: April 5, 1973 ? Jupiter ? Saturn (August 1979)

« Inside » or « outside » flyby? 21 000 km above the clouds.



**First close-up pictures
of Saturn. Another
ring found, two new
small moons**





**6 encounters, but
more than 20 y. of
designing, building,
planning, analysing**

**More new information
that had been collected
in 370 years Earth obs.**

**DIVERSITY
RICHNESS**

Never before observed:

- Atmospheric motions (in details) of a giant spinning sphere of H and He
- Planet-sized objects such as Ganymede, Callisto, .
- Volcanic activity on a Moon-sized satel.: Io
- Magnetospheres of giant planets in situ
- Unexplored electric and magnetic fields
- Detailed structures in ring systems
- Text books have to be rewritten
- Like to be at the crow's nest of a ship, landfall, passage ? stange new islands

**WE ALWAYS EXPECTED
THE UNEXPECTED:**

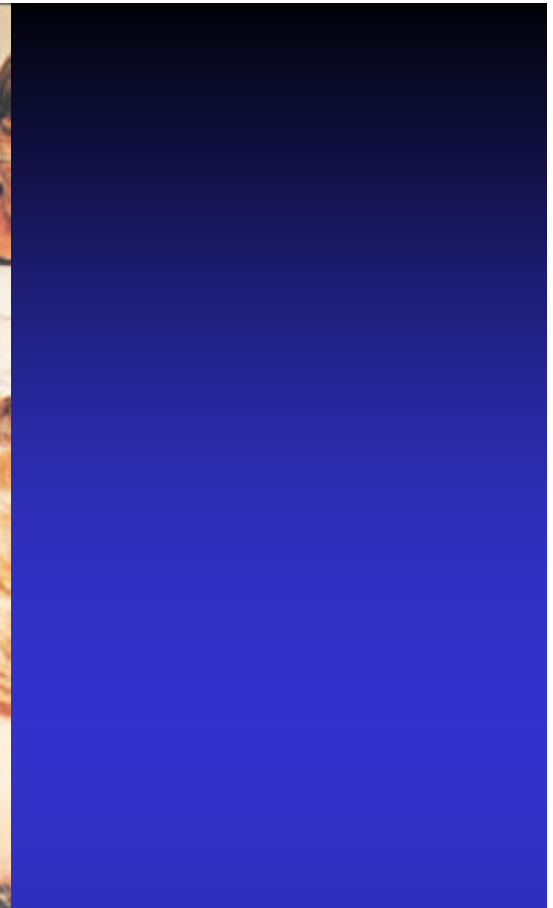
**WE WERE NEVER
DISAPPOINTED**

(bets)

Risky venture

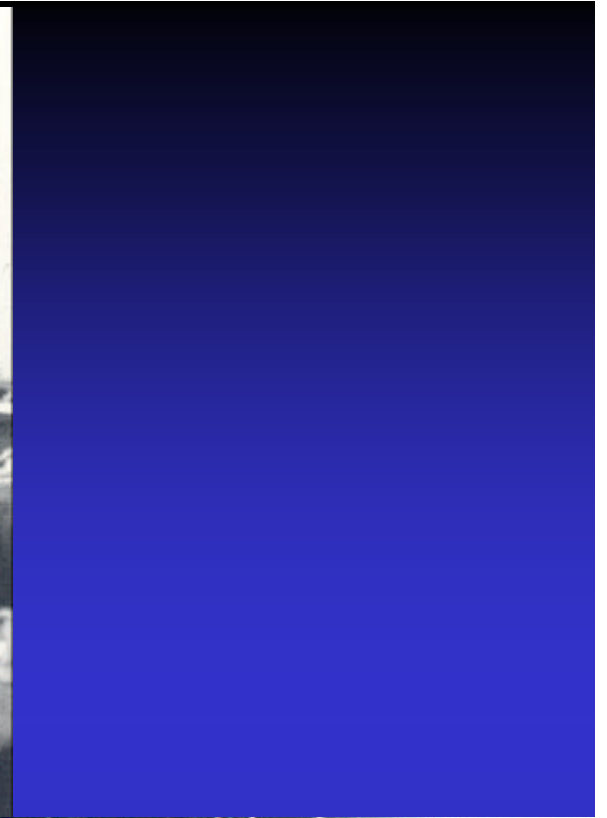
- Immense distances of cold, dark, airless space
- Unexplored fields of parti. and magnetic forces
- Spacecraft not designed for Uranus and Neptune
- Reliability: 5 ? more than 12 years
- 1st year: « psychotic behaviour of computers on board
- Voyager 2: Failures radio receiver, scan platform
- Voyager 2: slightly deaf and rhumatisms
- Programs rewritten: More « intelligent » at the end (techno. end 60s)
- « Repaired » between Saturn and Uranus
- Young lady ? Experienced old lady





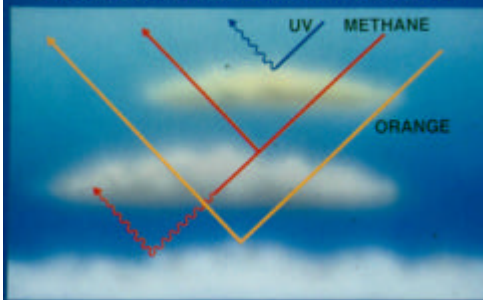
TV monitors in JPL rooms





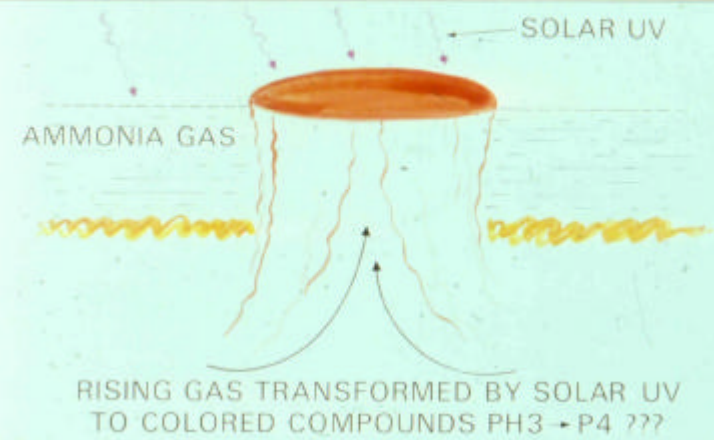


CLOUDS IN DIFFERENT FILTERS



Voyager

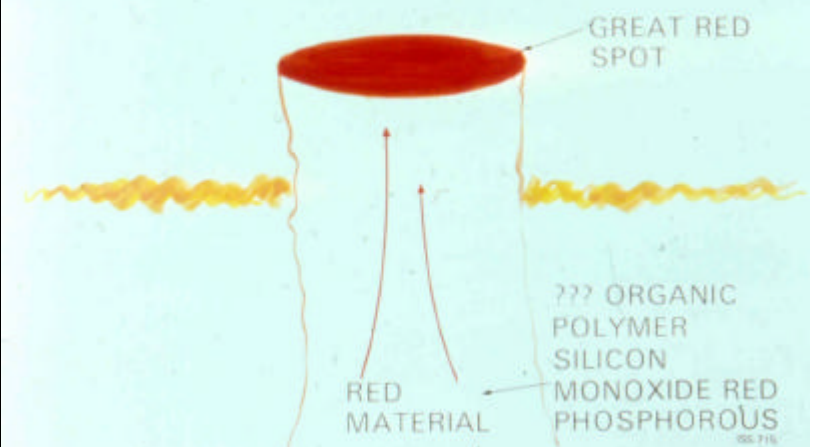
IMAGING GREAT RED SPOT (EXTERNAL MODEL)



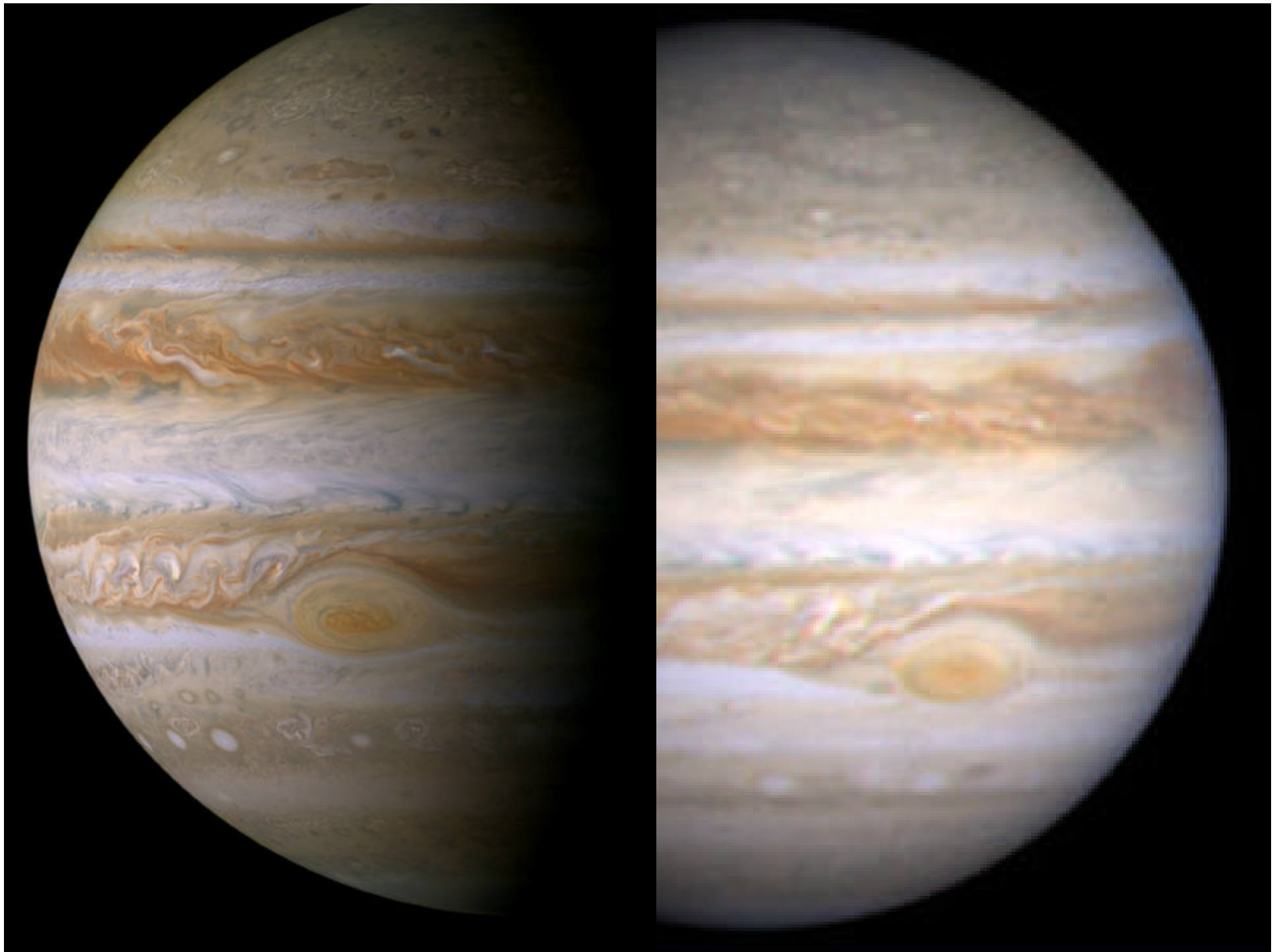
ISS 714

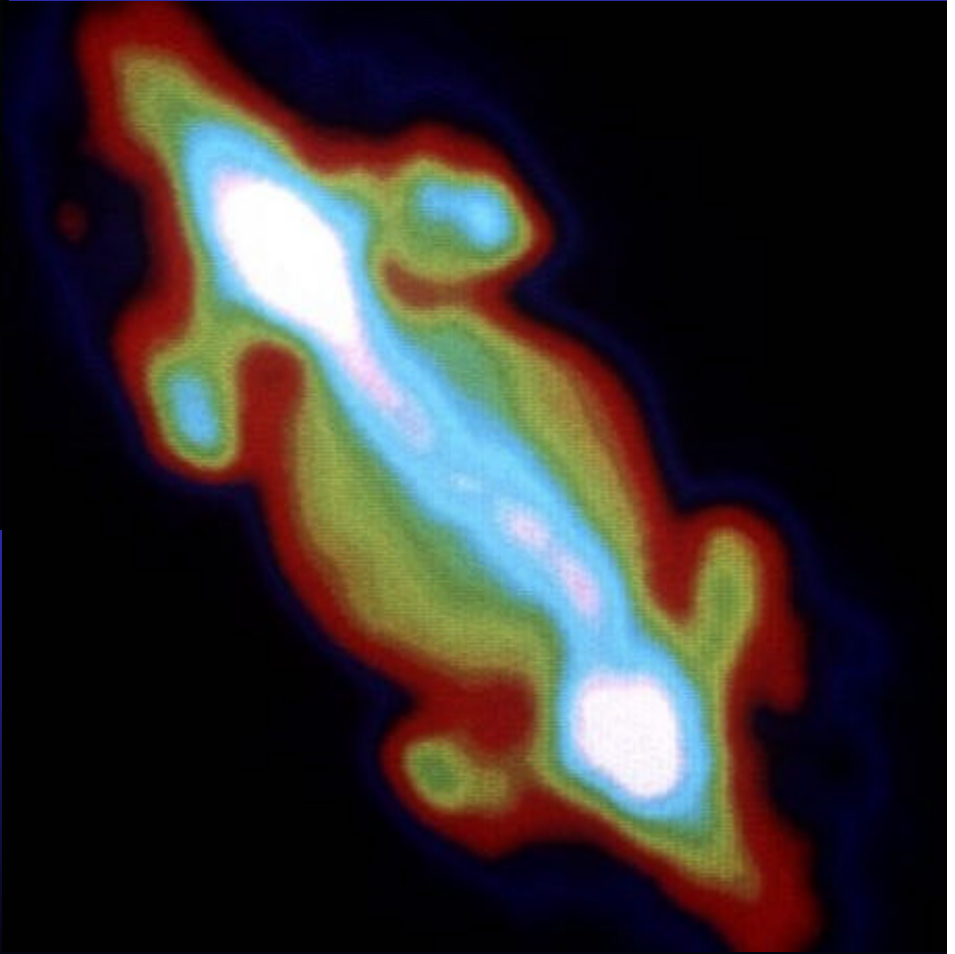
Voyager

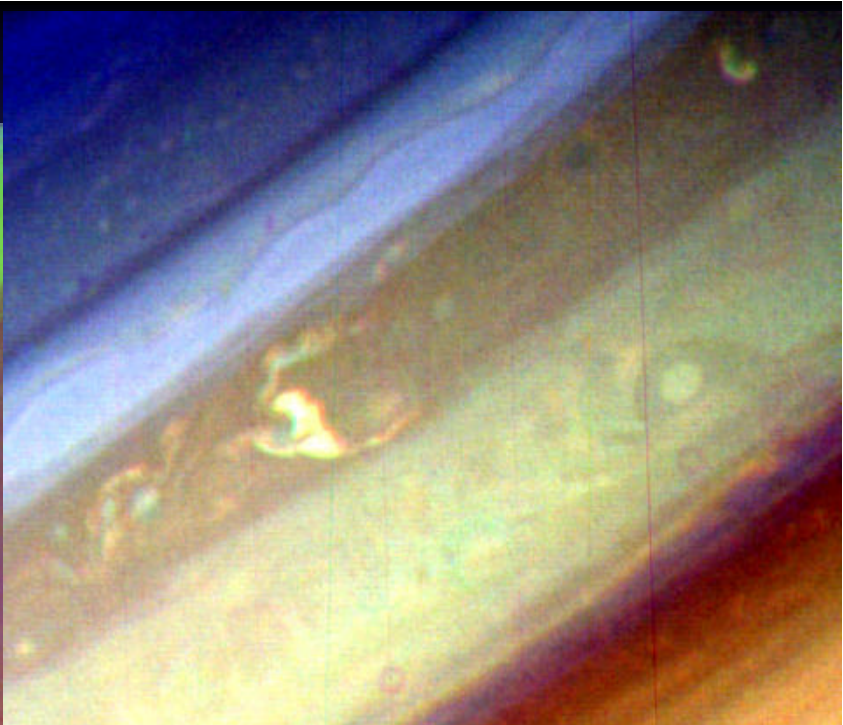
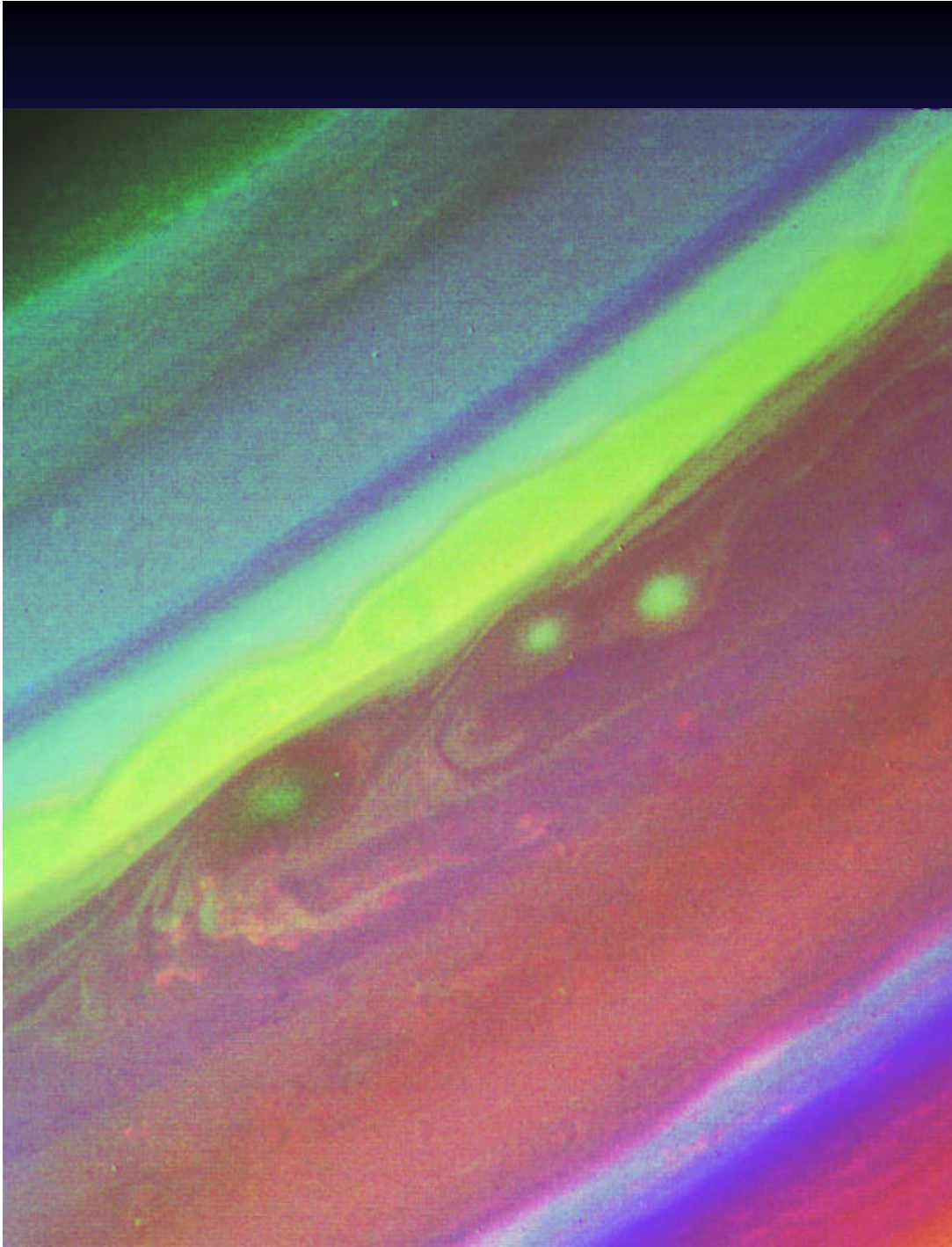
IMAGING GREAT RED SPOT (INTERNAL MODEL)



ISS 715



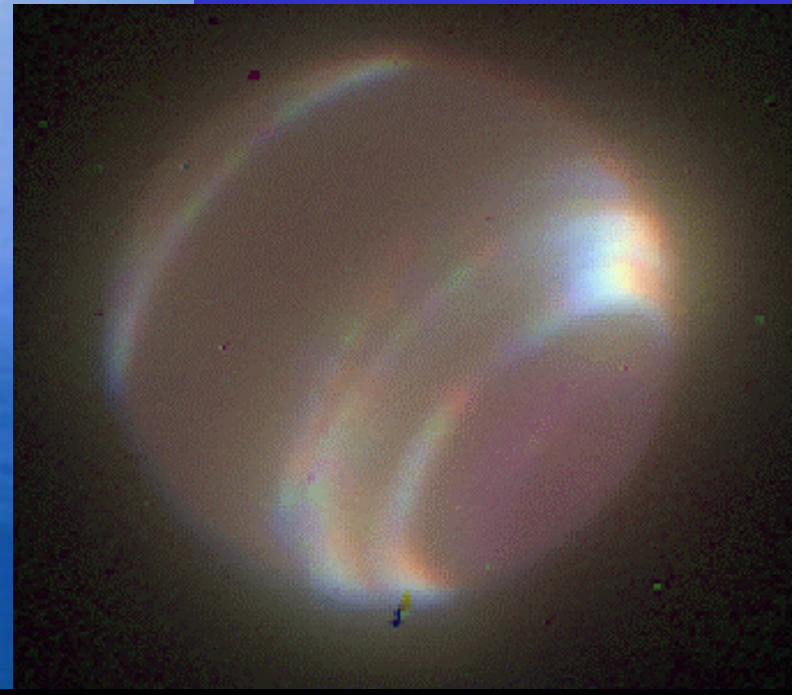
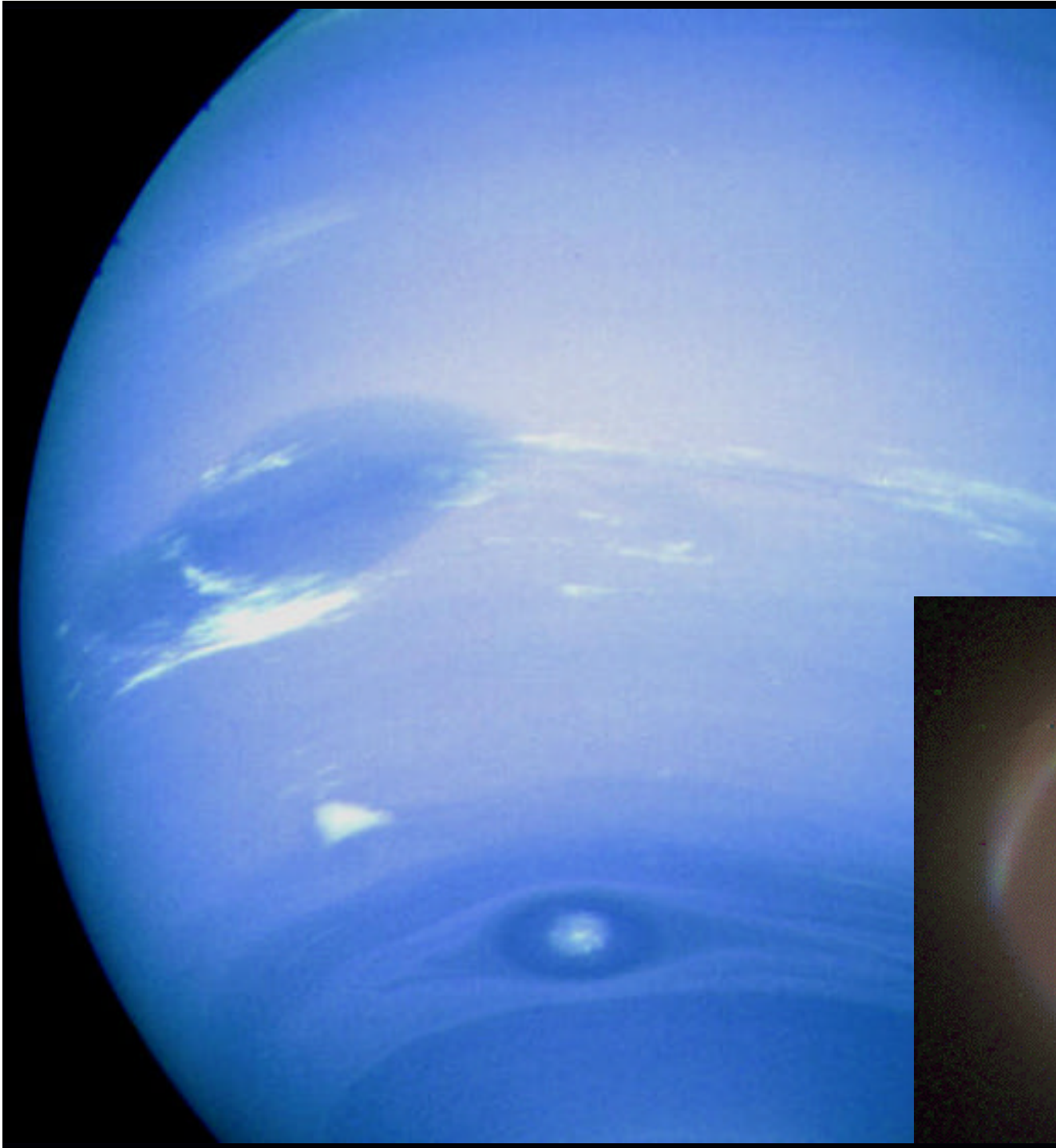


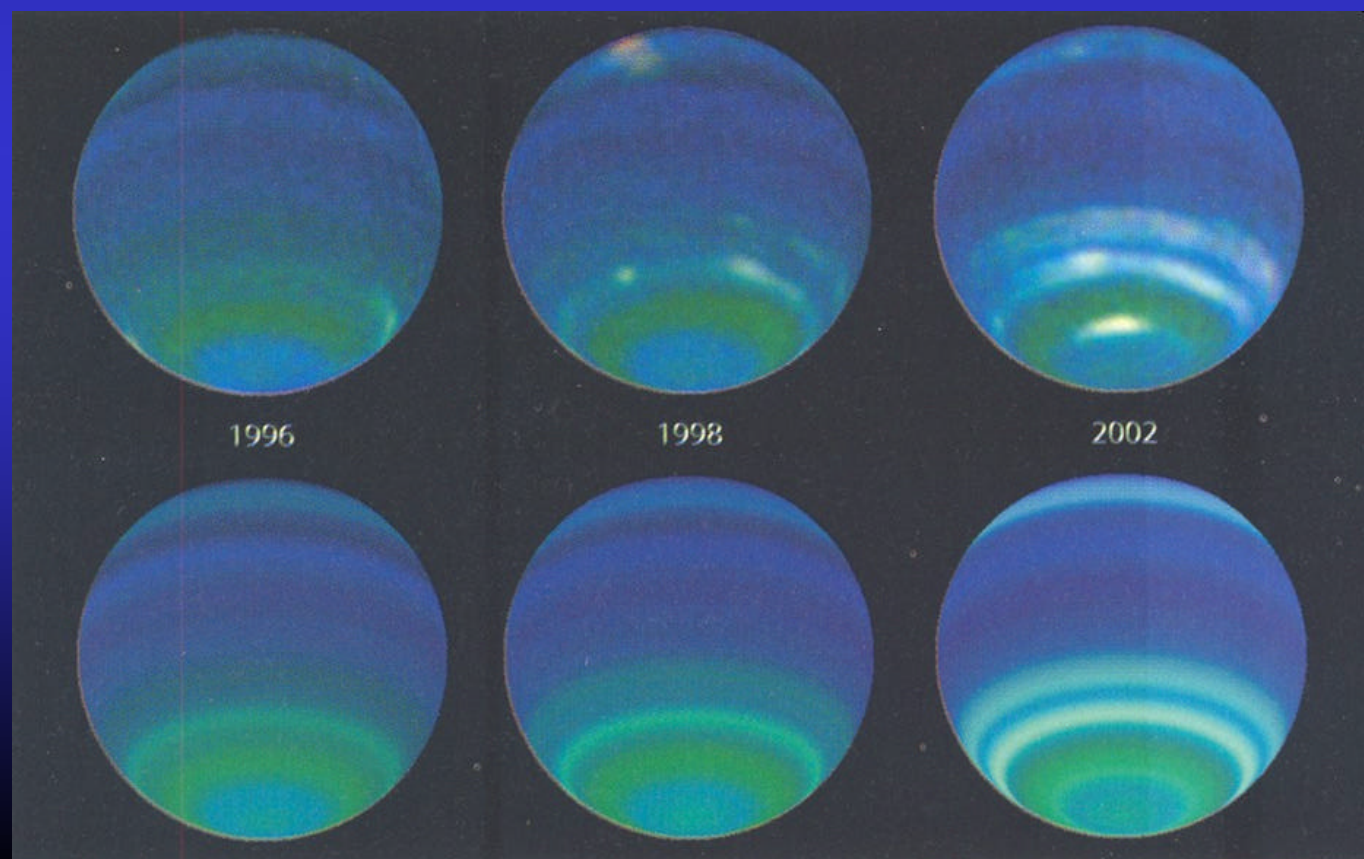


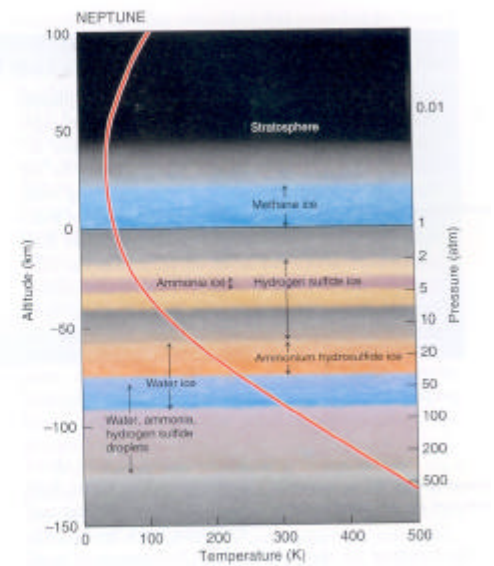
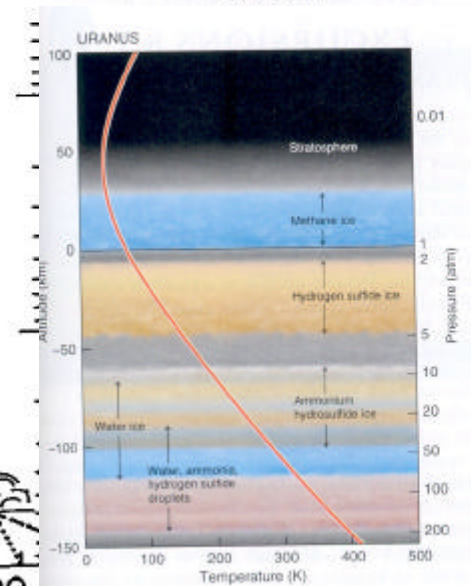
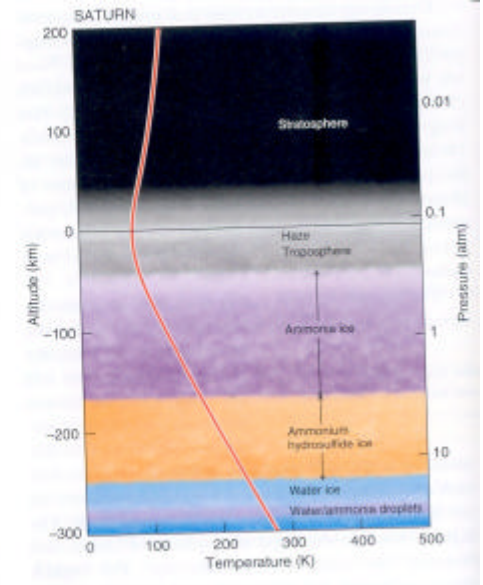
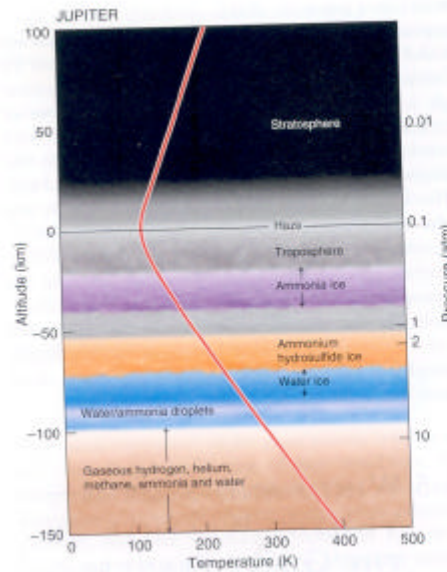
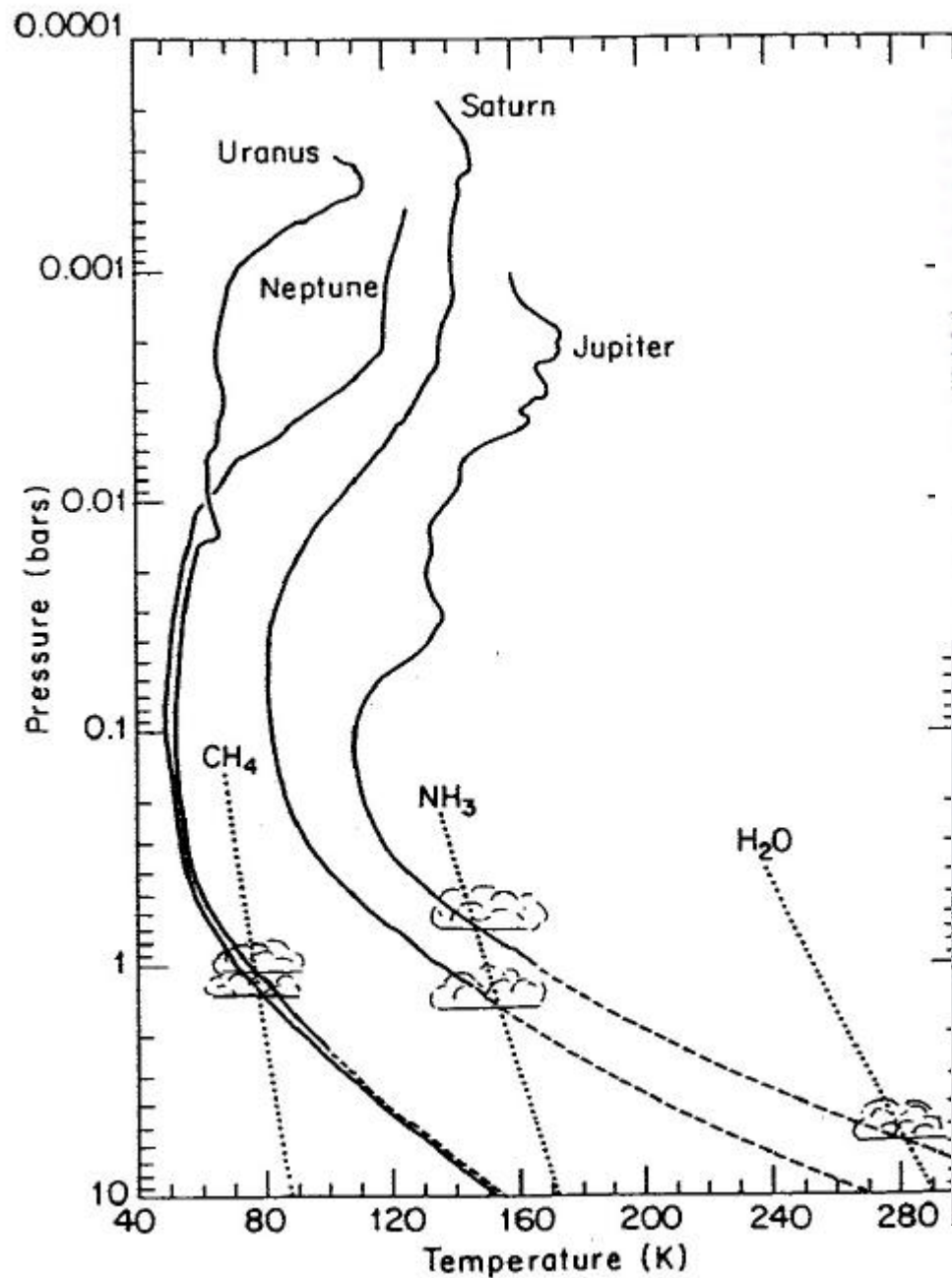


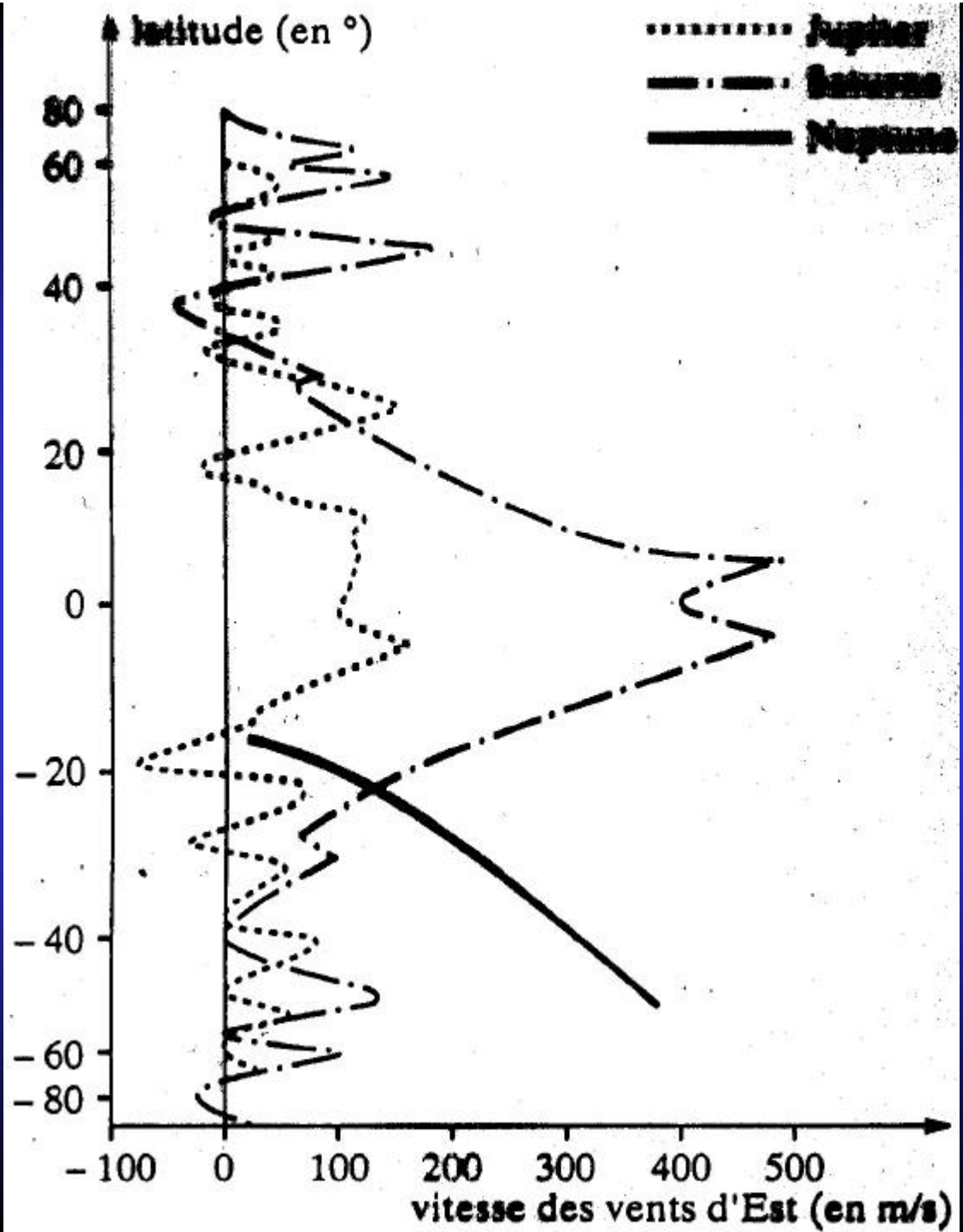
Space shuttle explosion

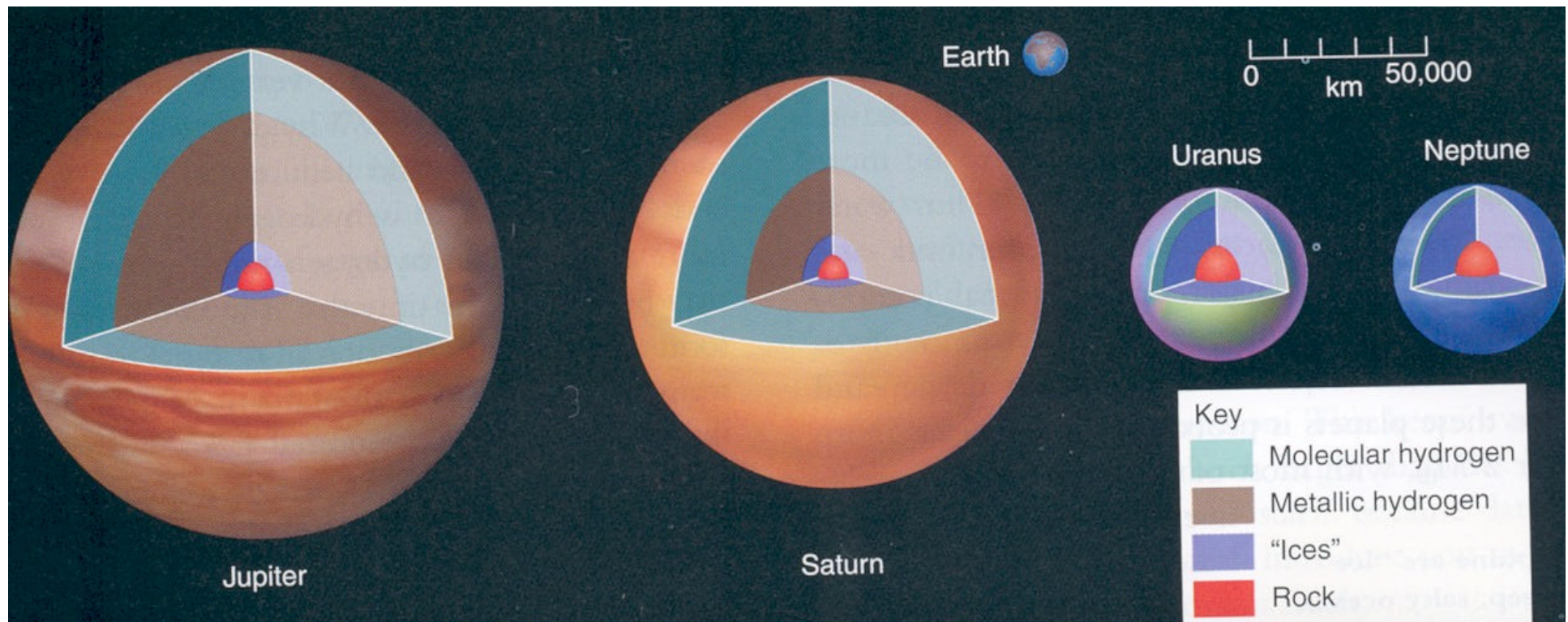
Sad encounter











Jupiter, Saturn and Neptune internal heat

2 gas giant planets

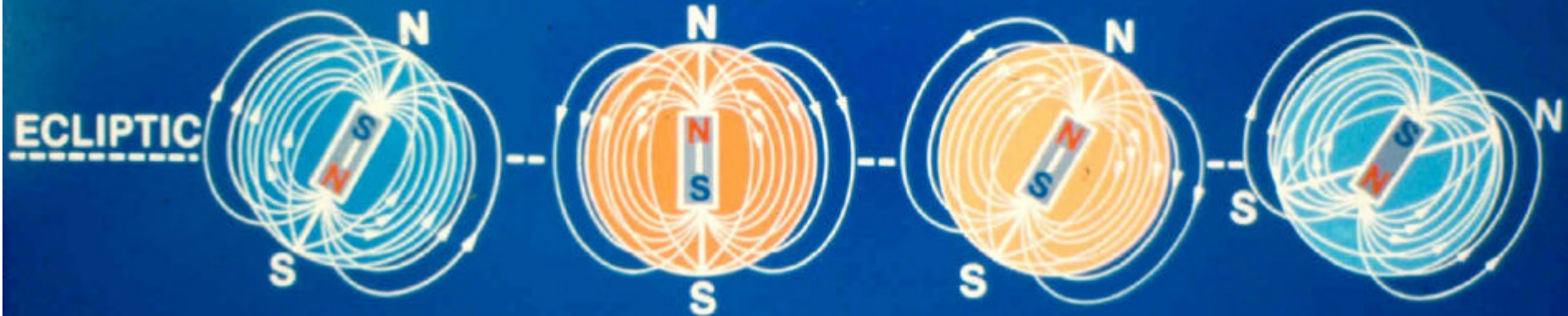
2 ice giant planets

EARTH

JUPITER

SATURN

URANUS



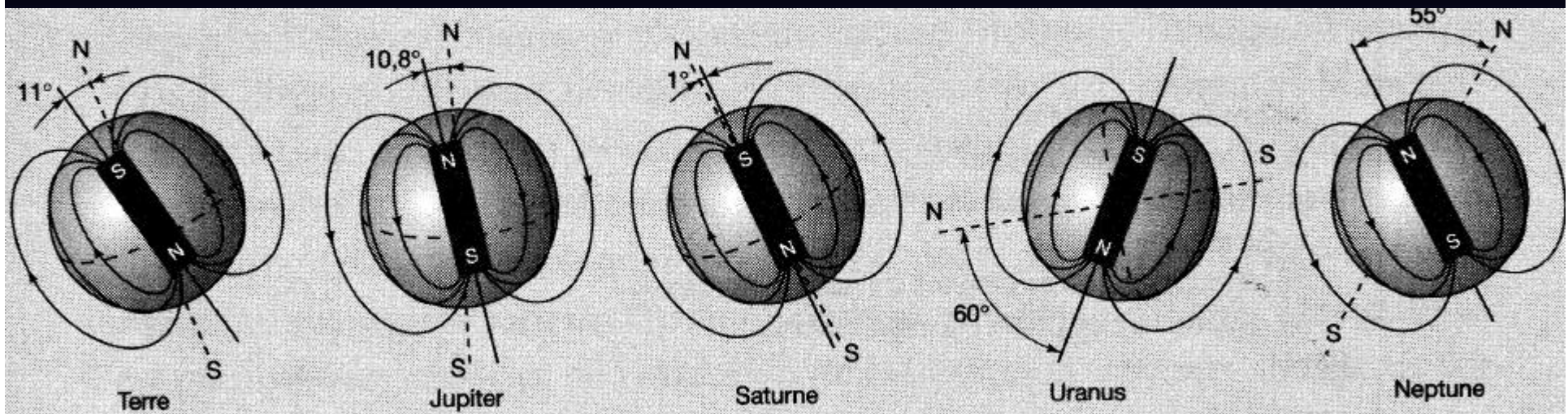
EARTH

JUPITER

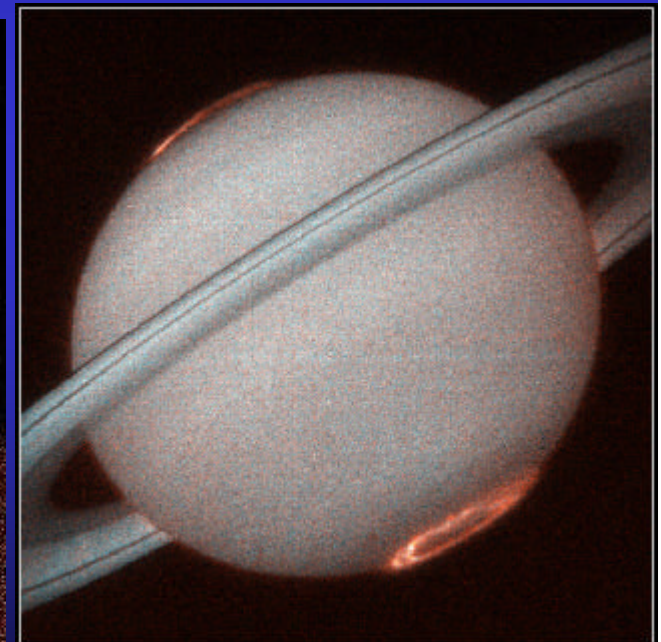
SATURN

URANUS

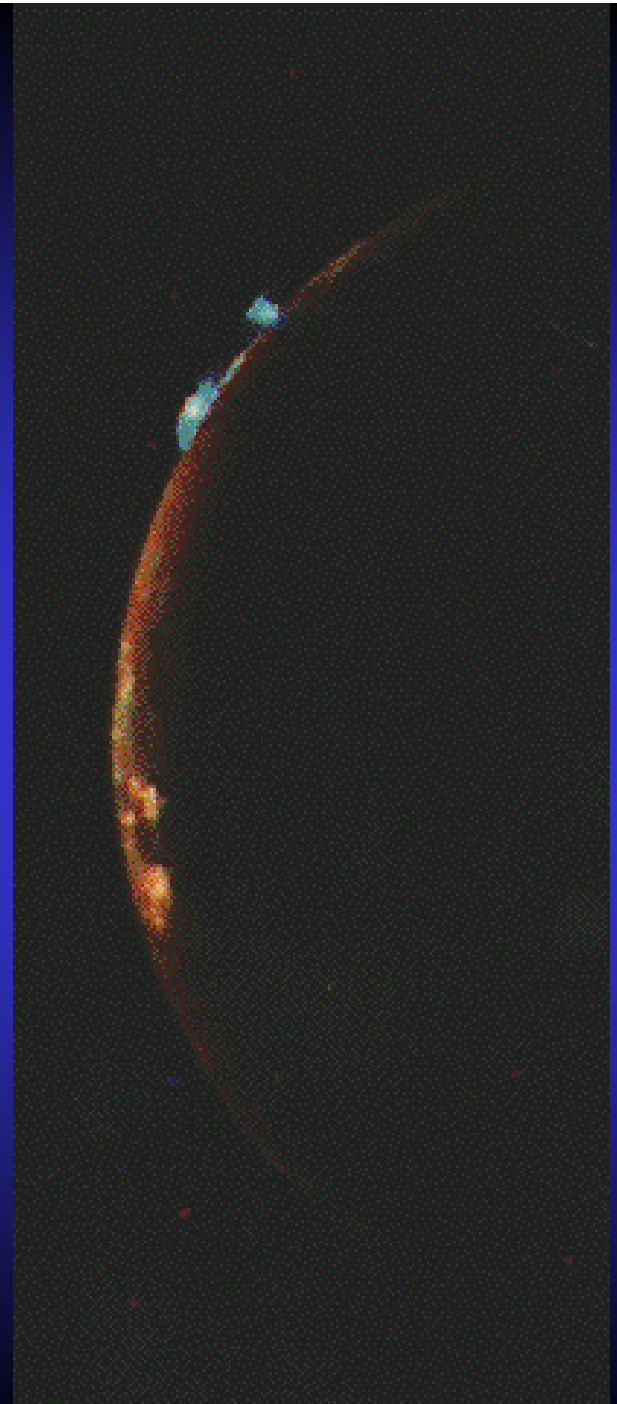


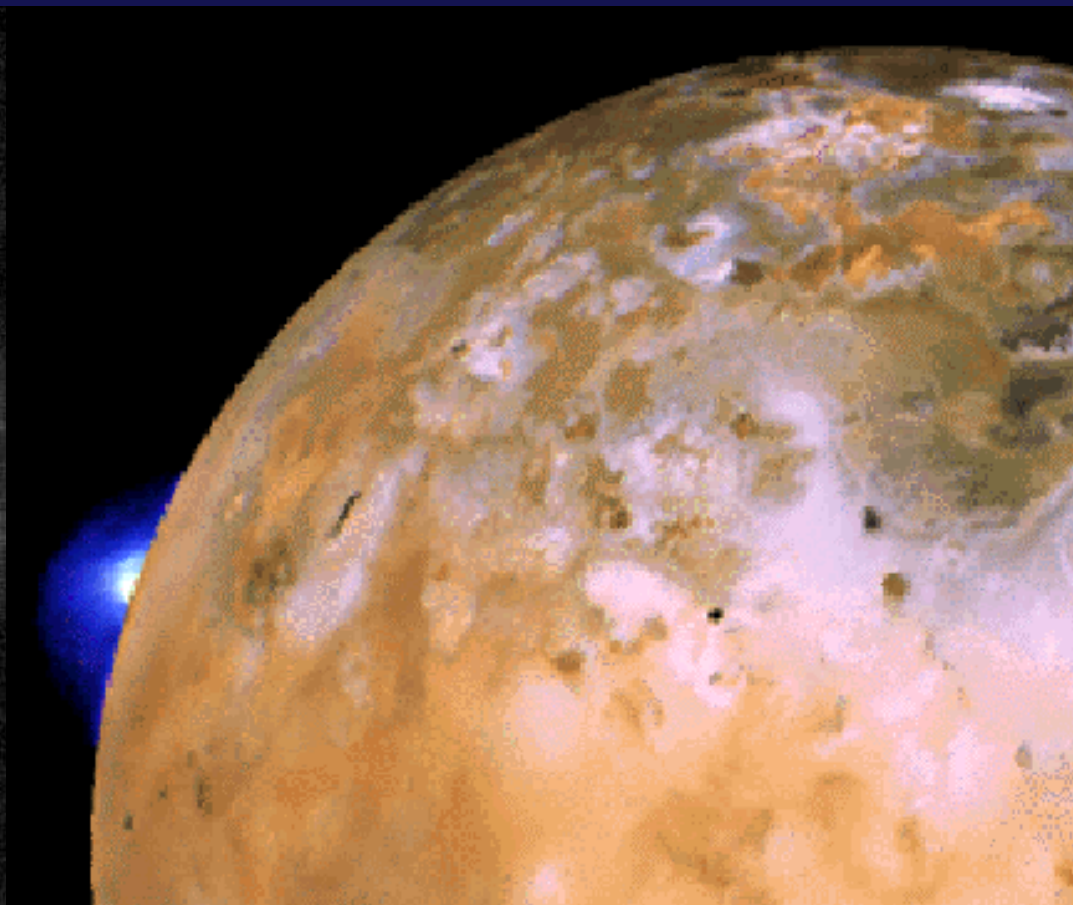
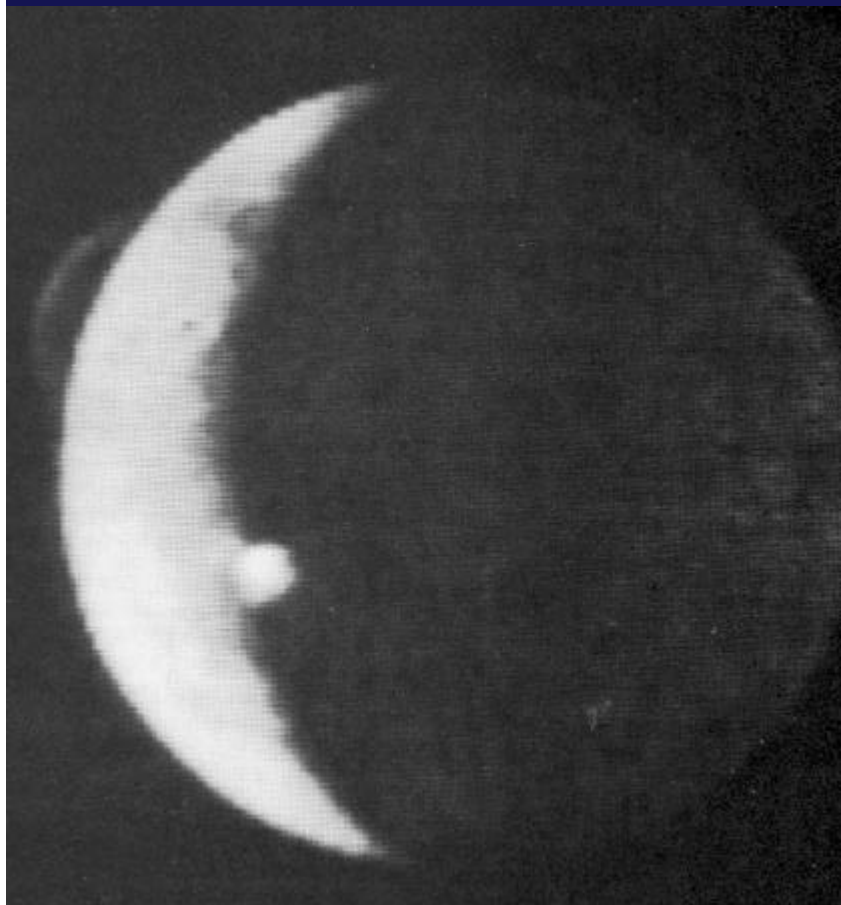


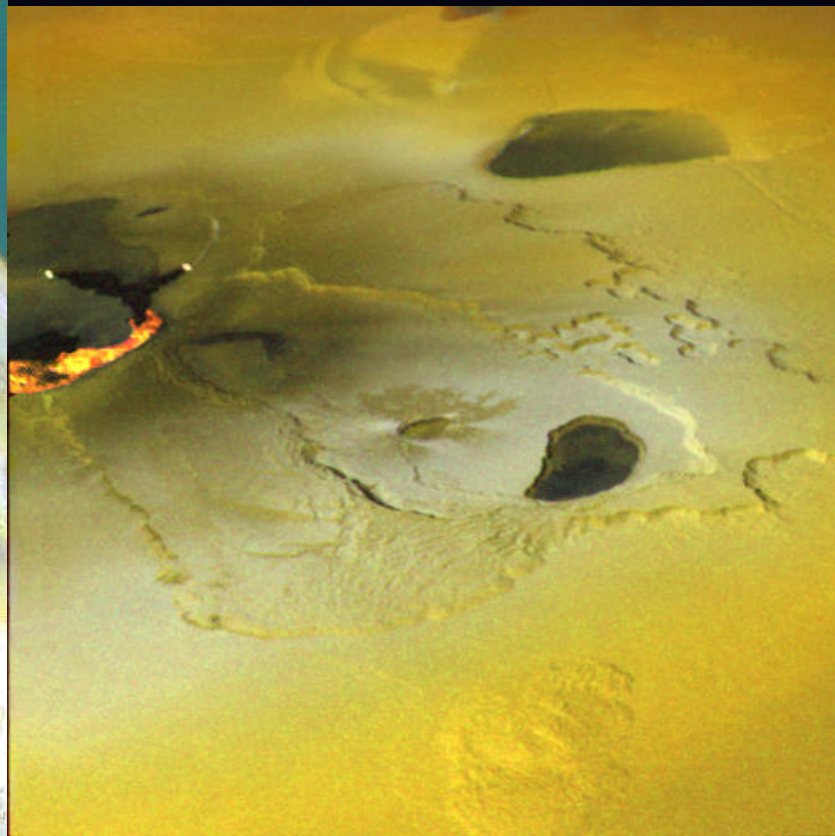
Io's plasma torus in Jupiter magnetosphere

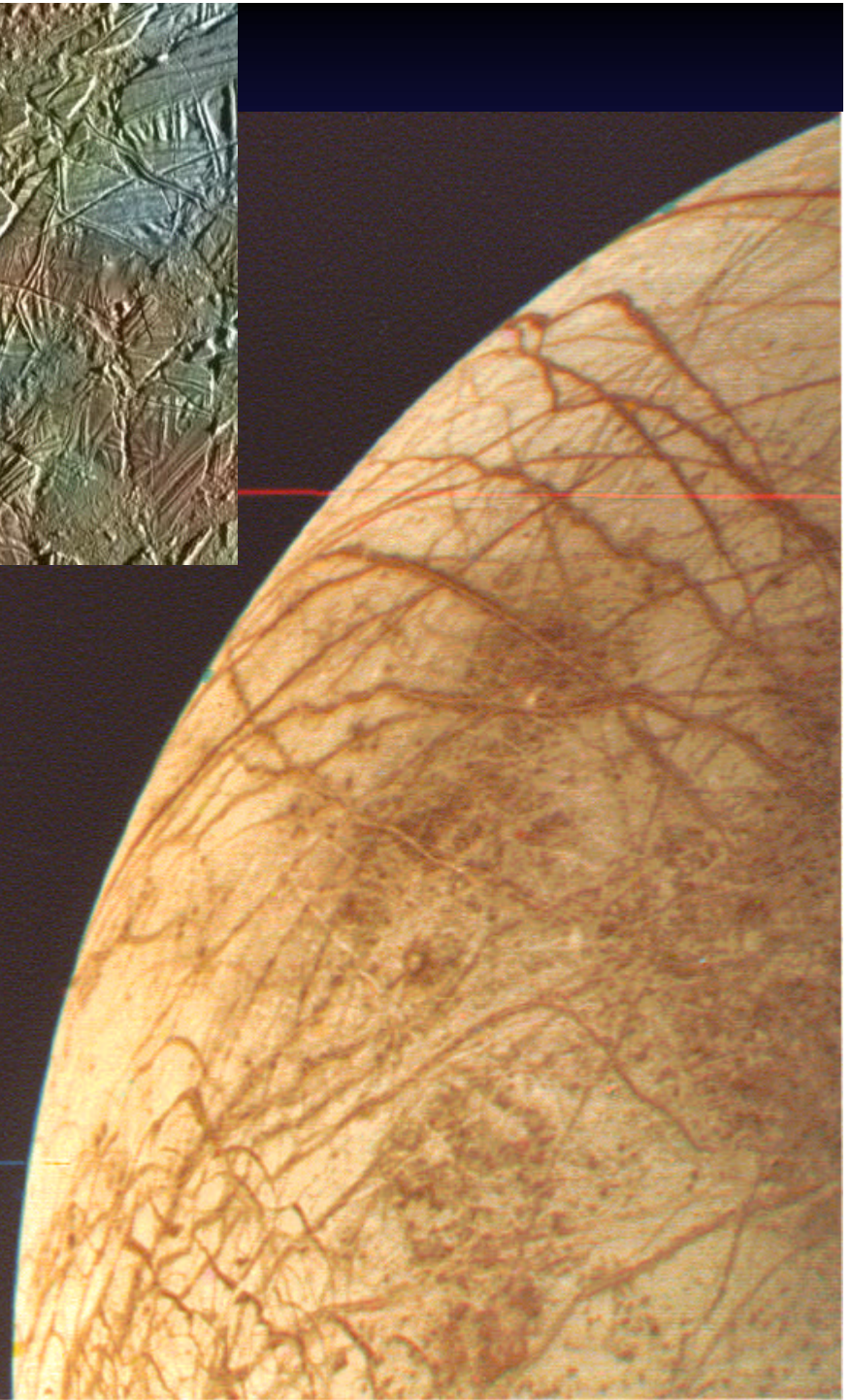
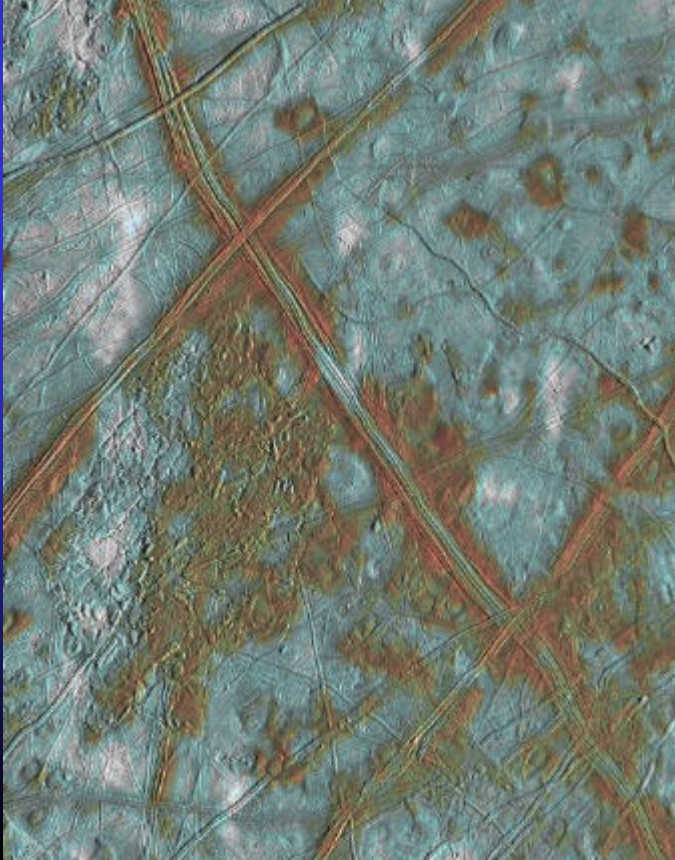
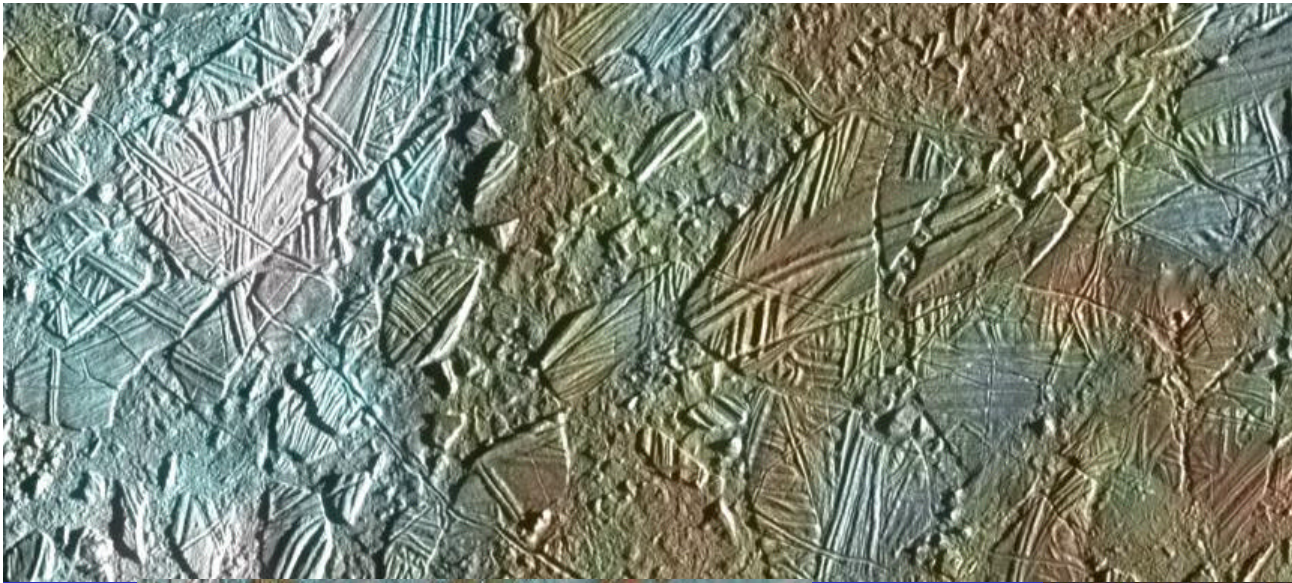


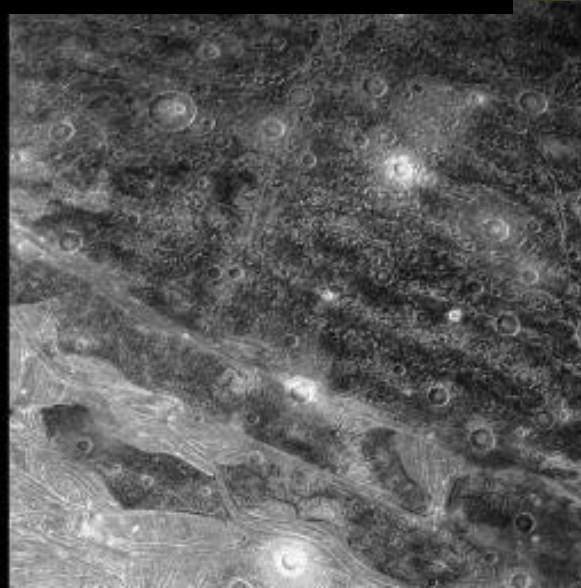
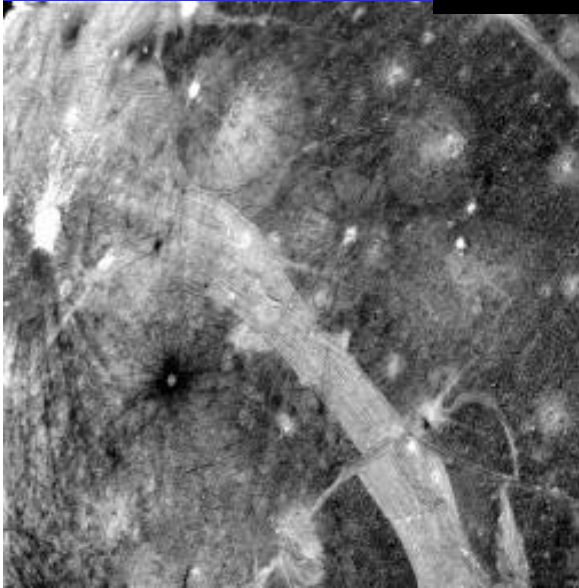
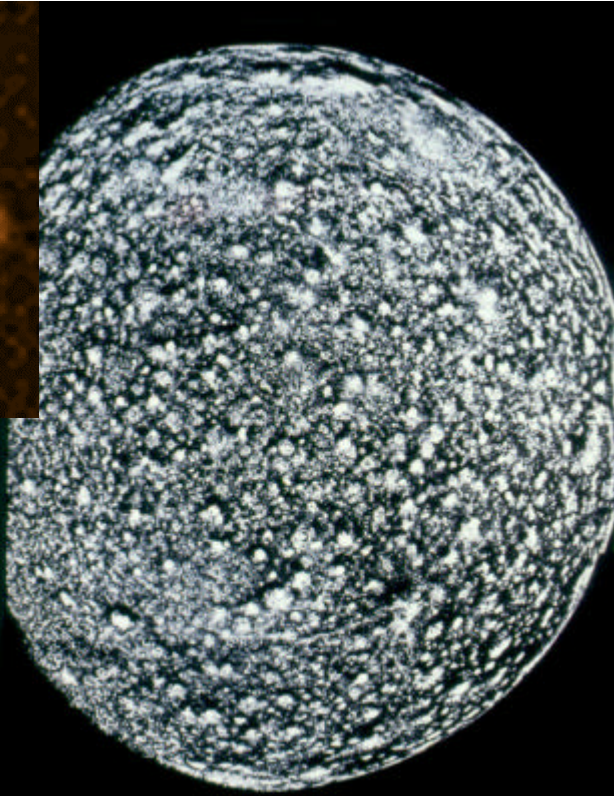
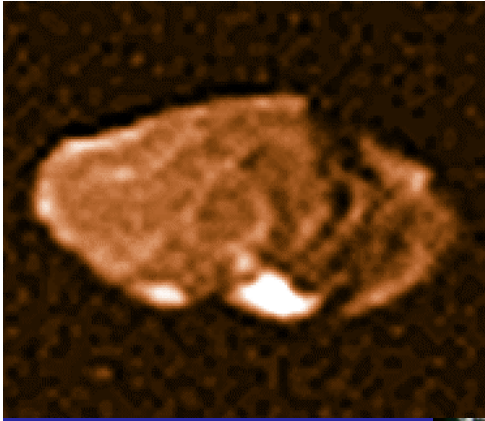
Saturn Aurora HST • STIS
PRC98-05 • ST ScI OPO • January 7, 1998 • J. Trauger (JPL) and NASA.

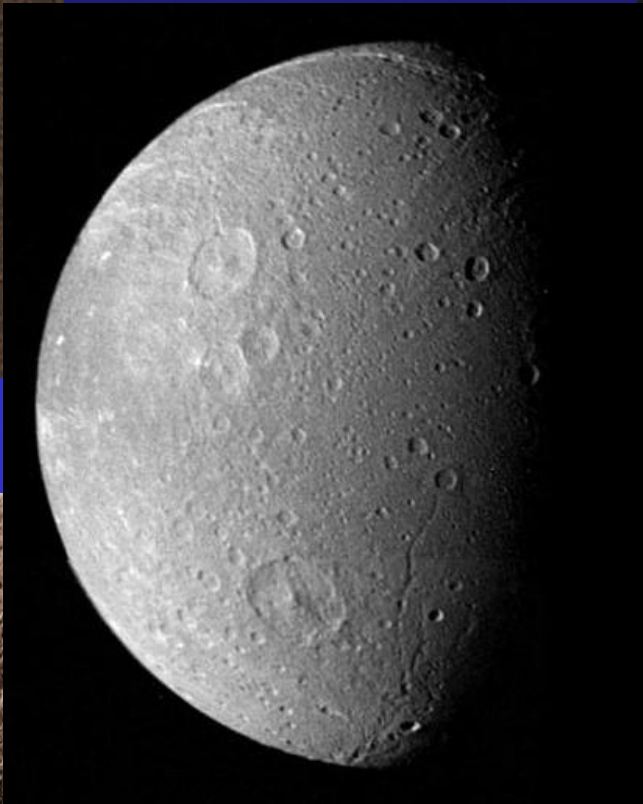
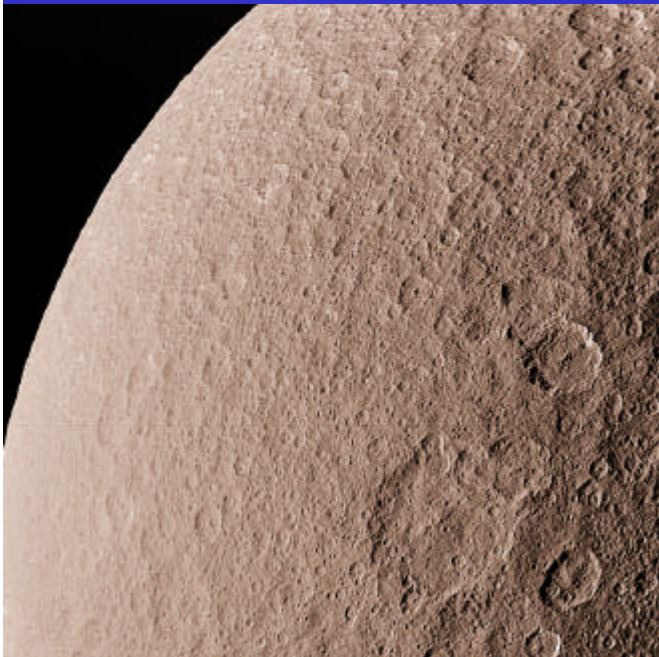
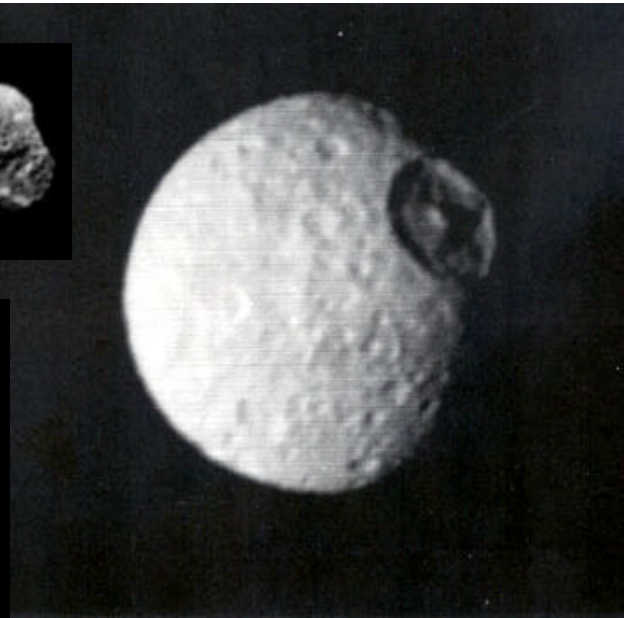
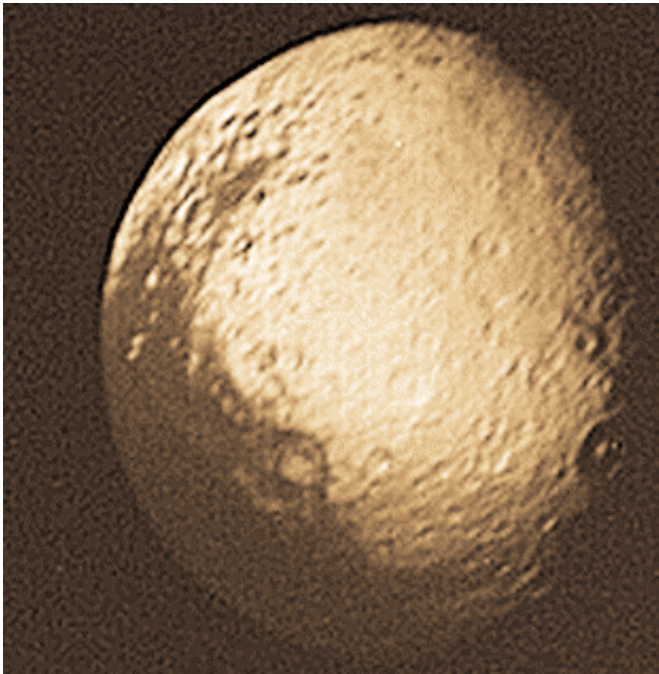


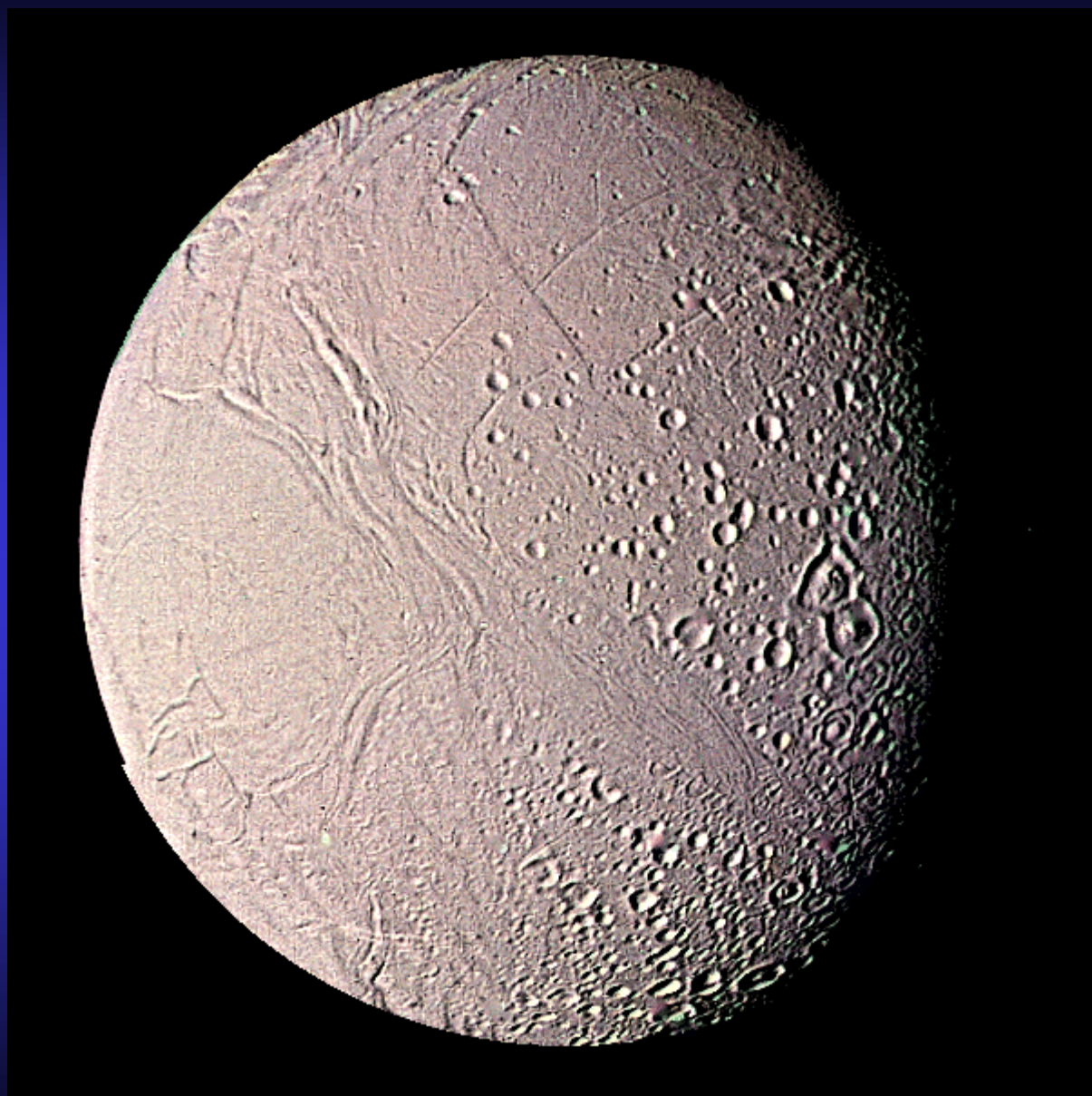




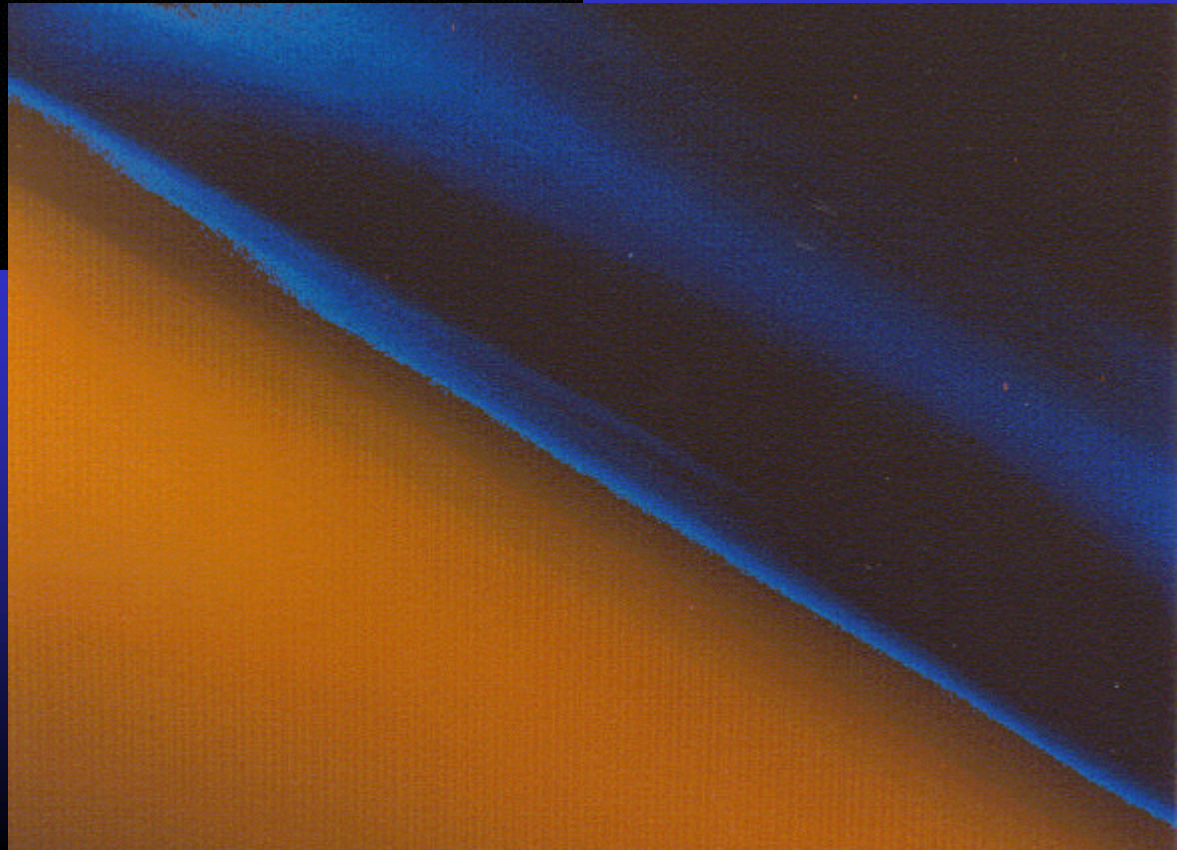
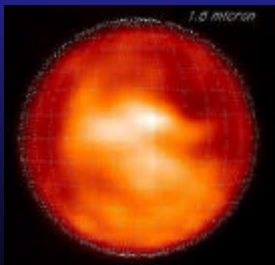


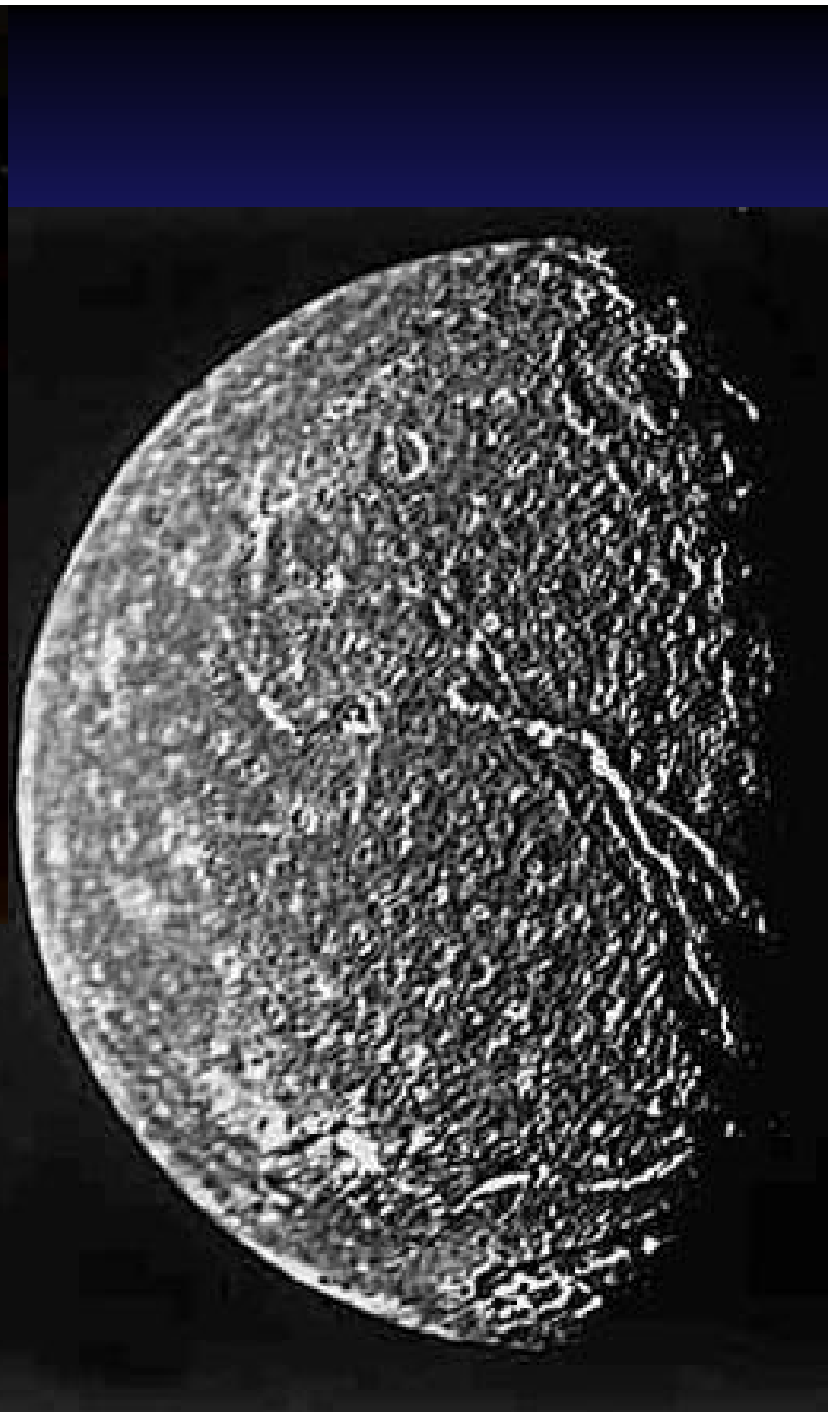


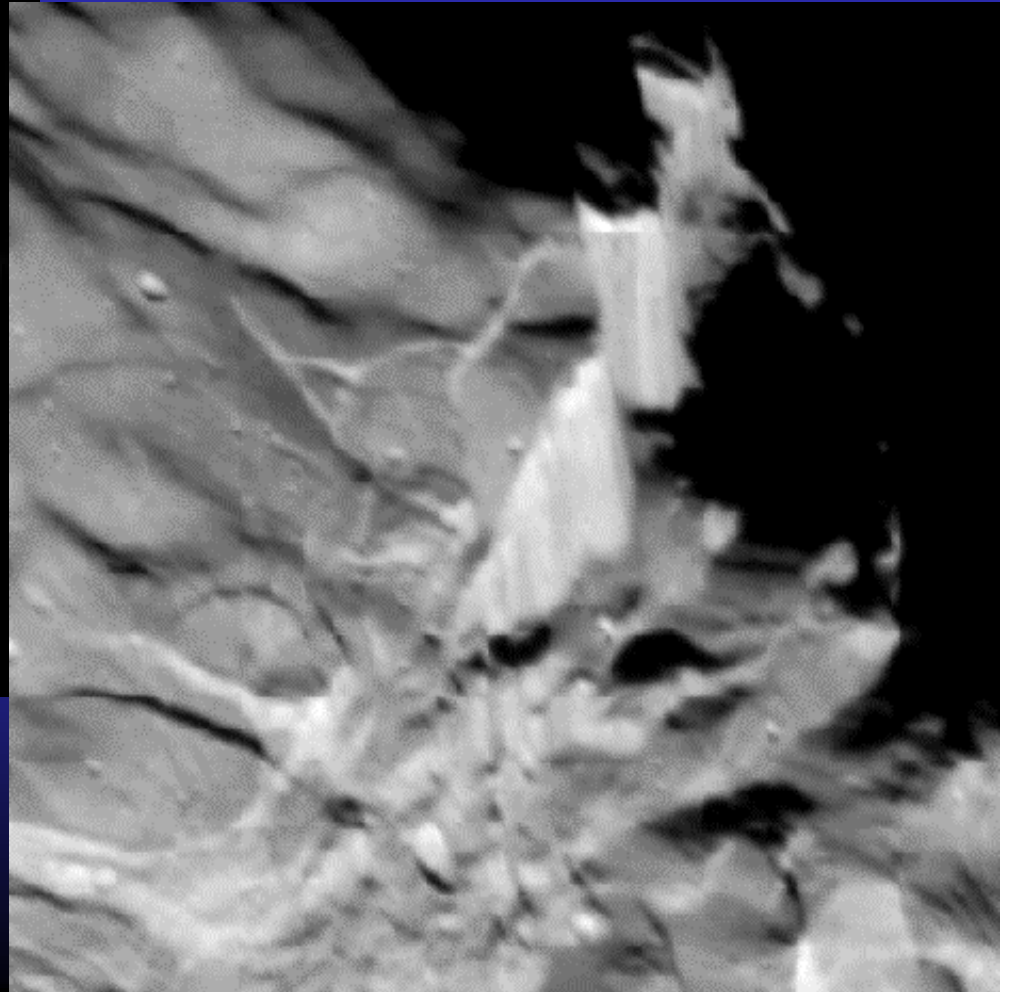


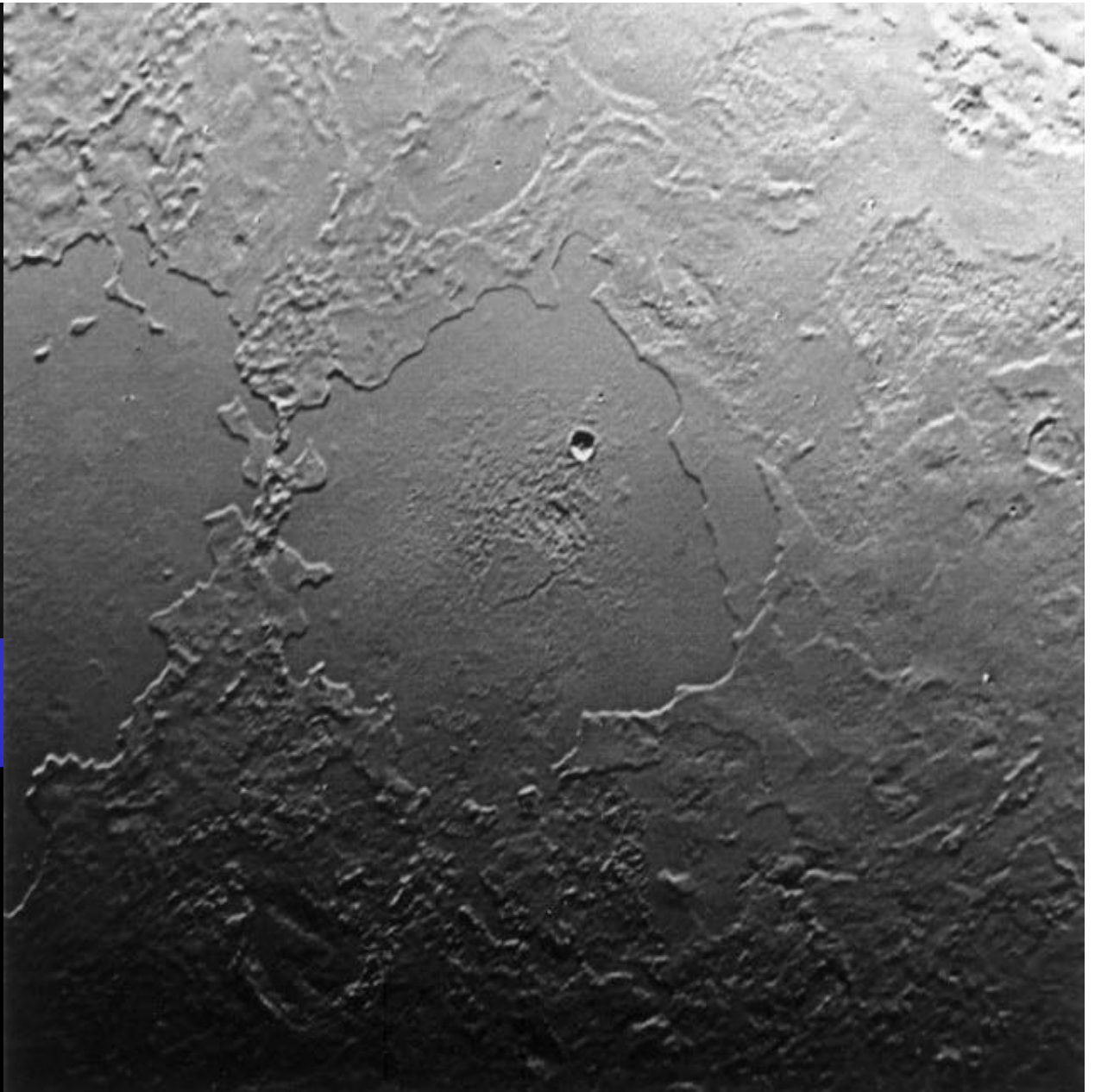
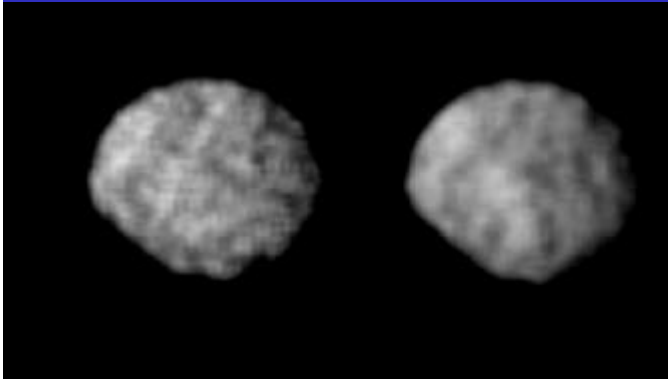
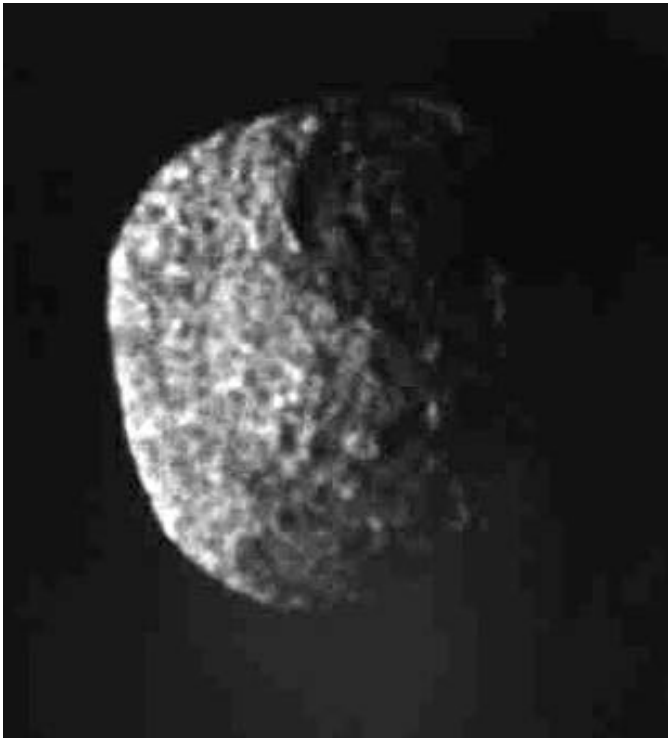


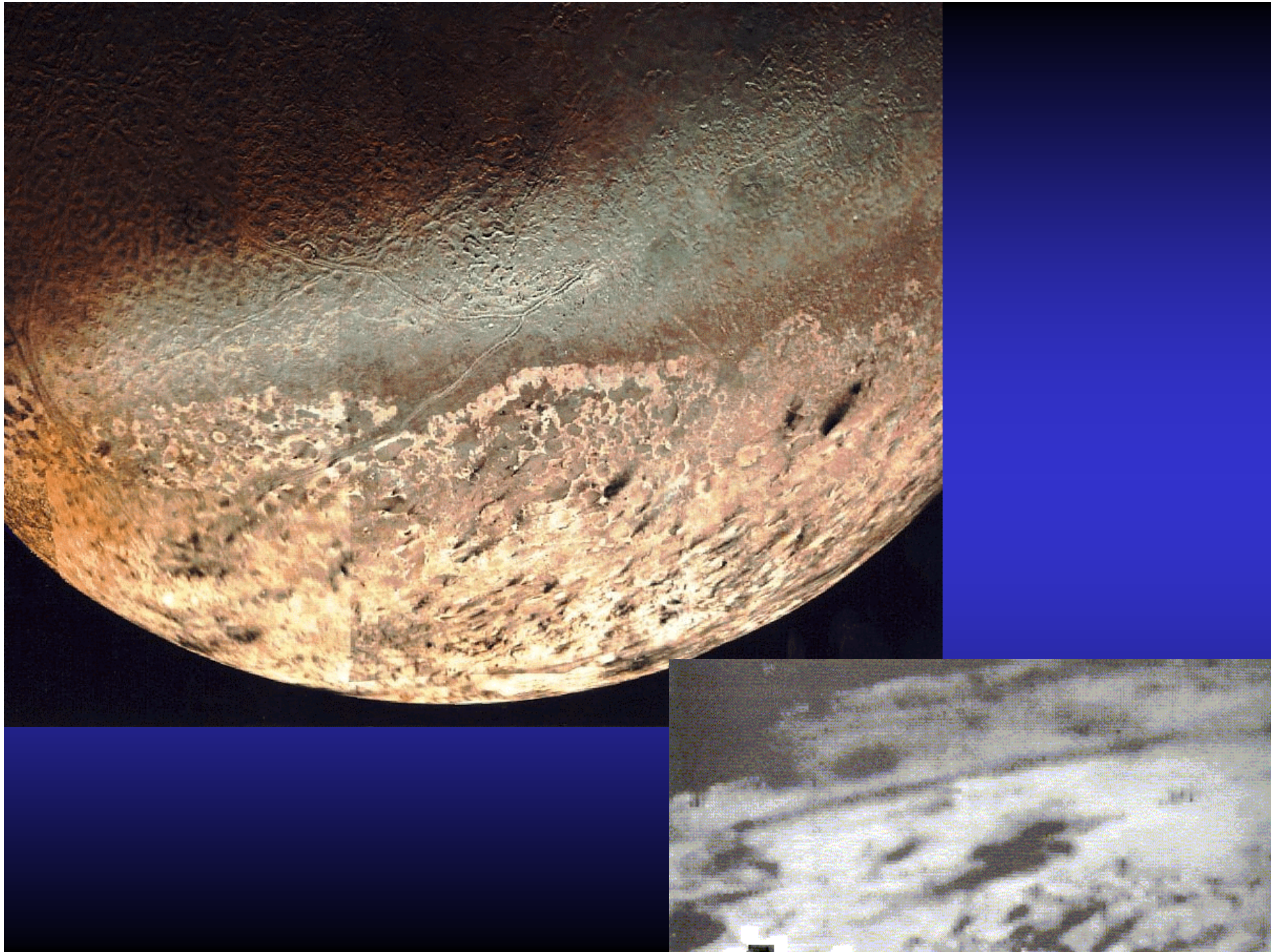
Earth, Titan, Triton





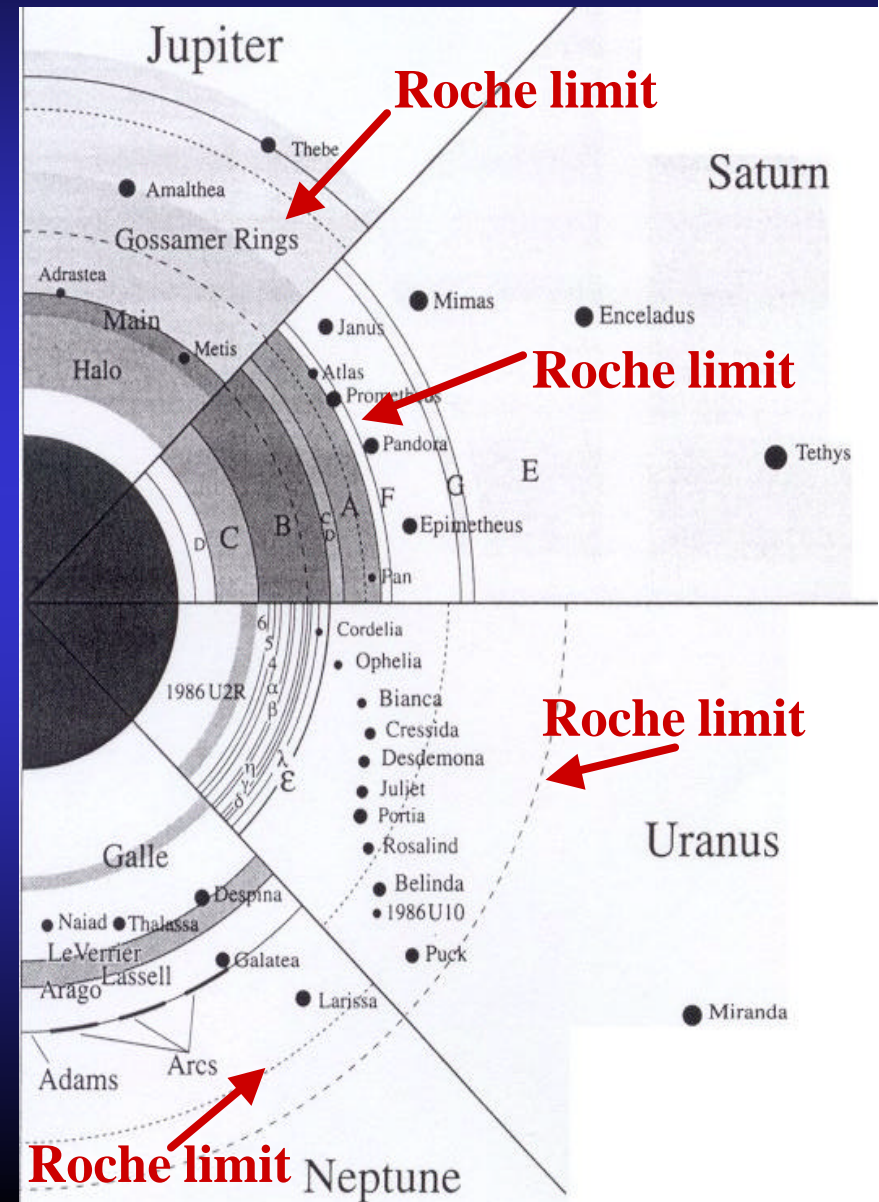


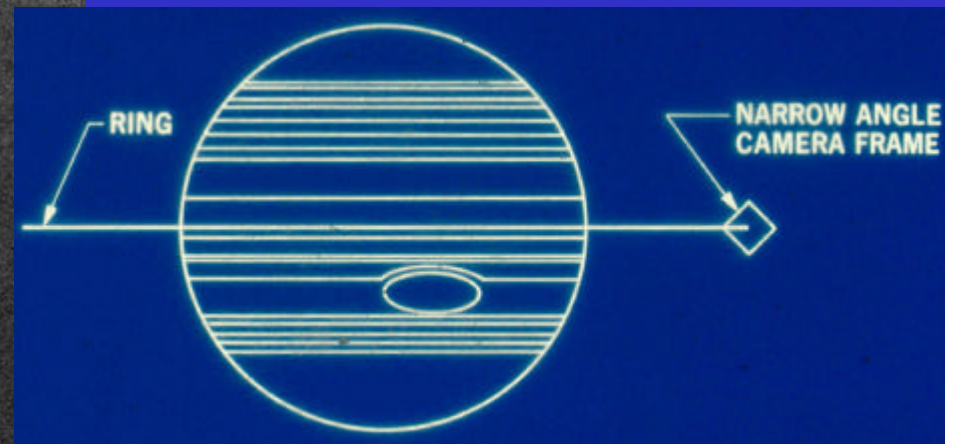
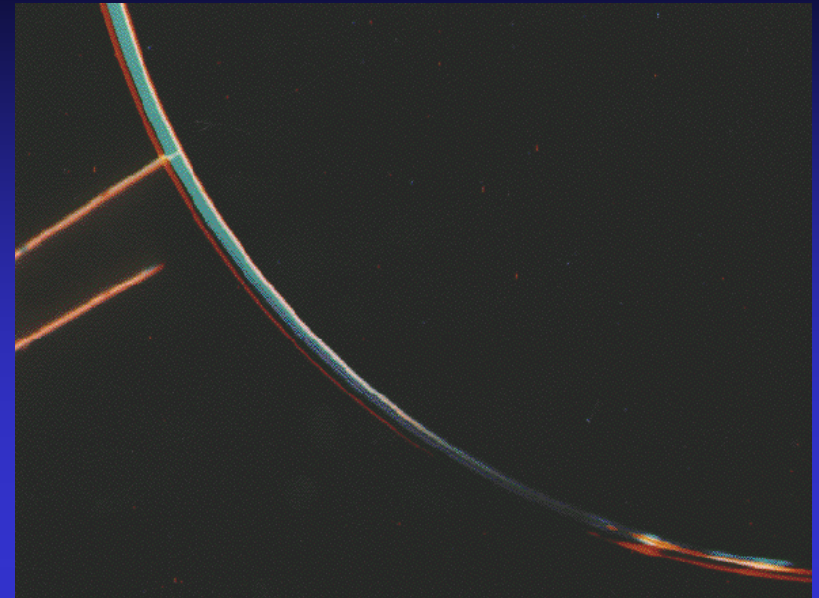
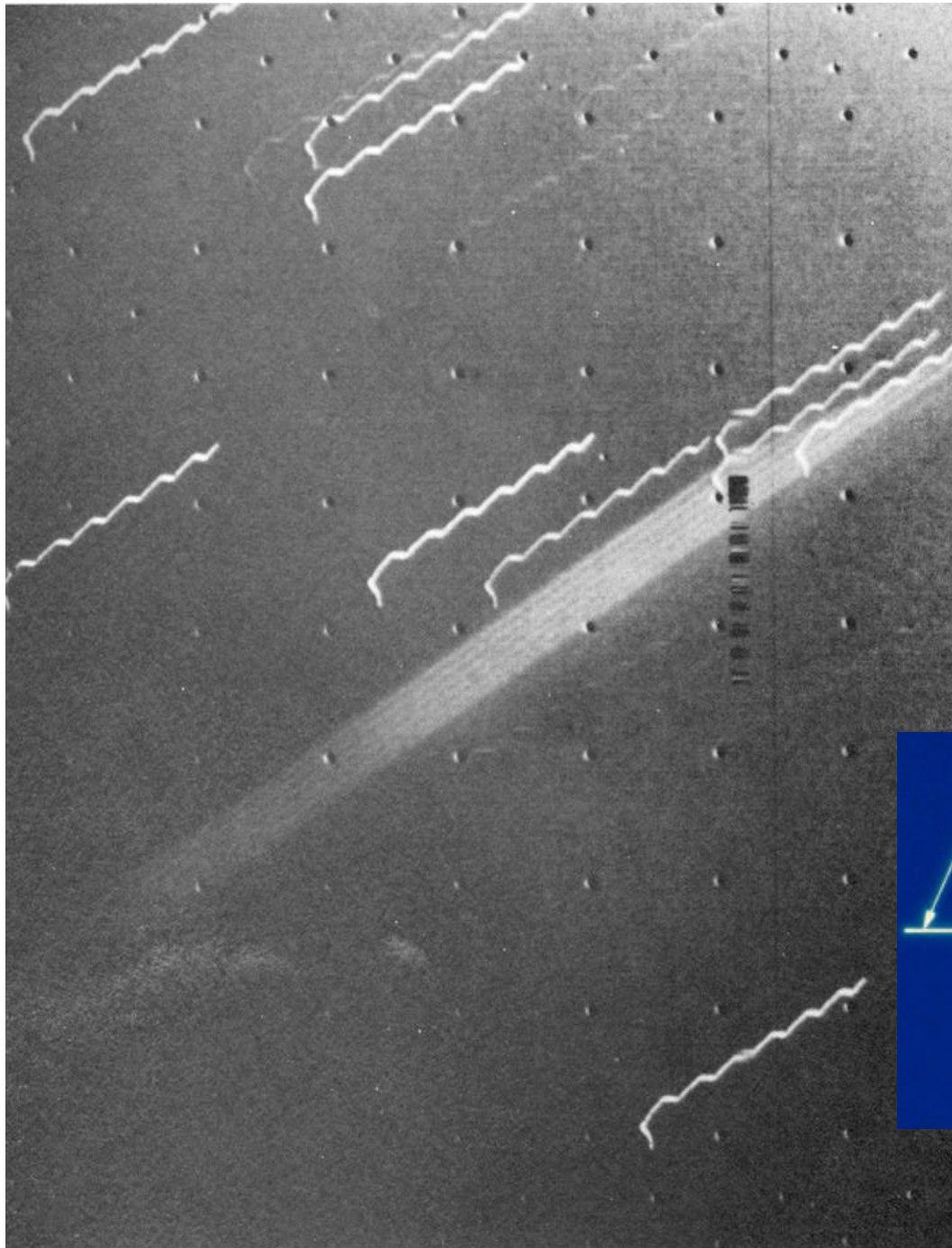


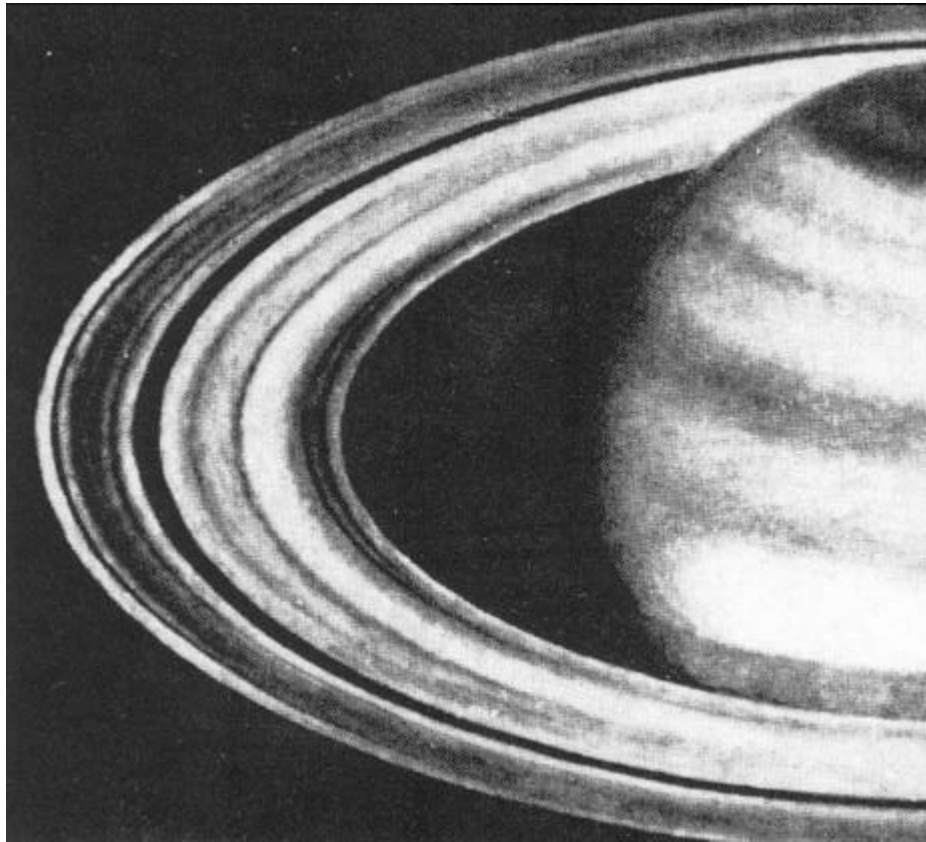


Planetary rings: diversity (perfume)

- < 1977: homogeneous rings with smooth edges
- Since 1977:
 - Heterogeneous rings with sharp edges
 - Discovery of Uranus', Jupiter's and Neptune's rings
 - Discovery of Neptune's arcs
 - More questions than replies

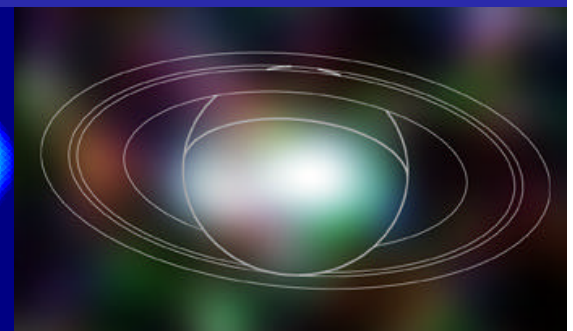
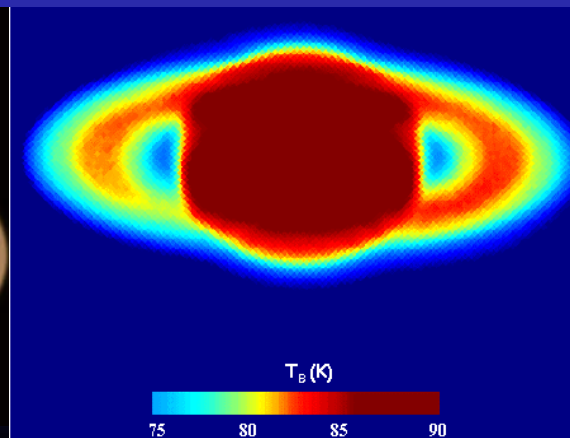
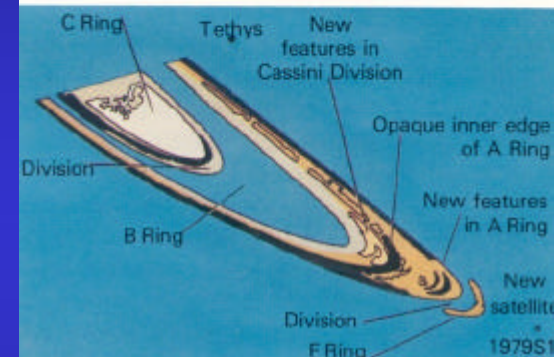
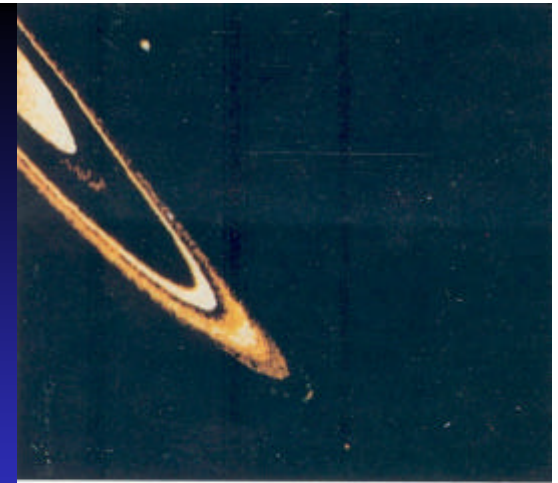


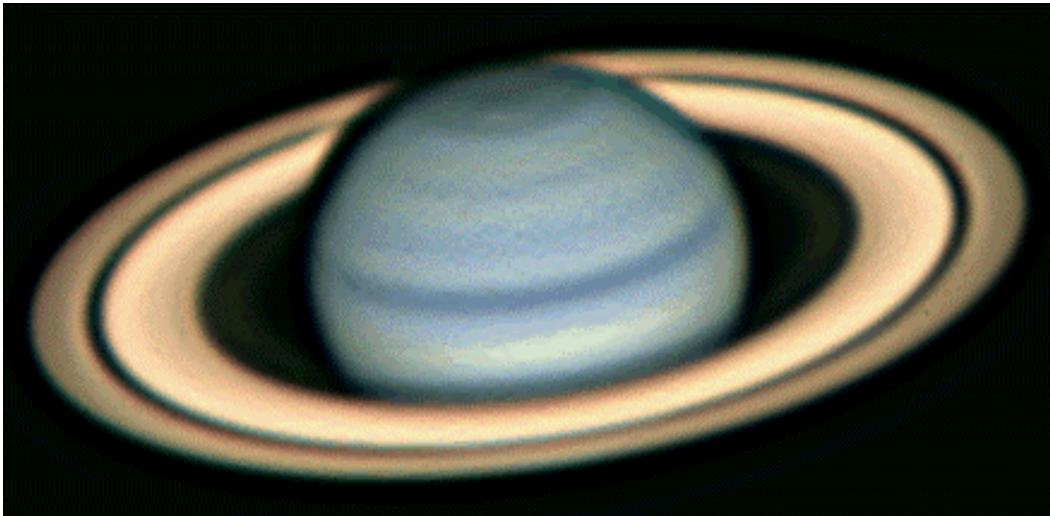




Bernard Lyot (1943)

**Pioneer
1979**



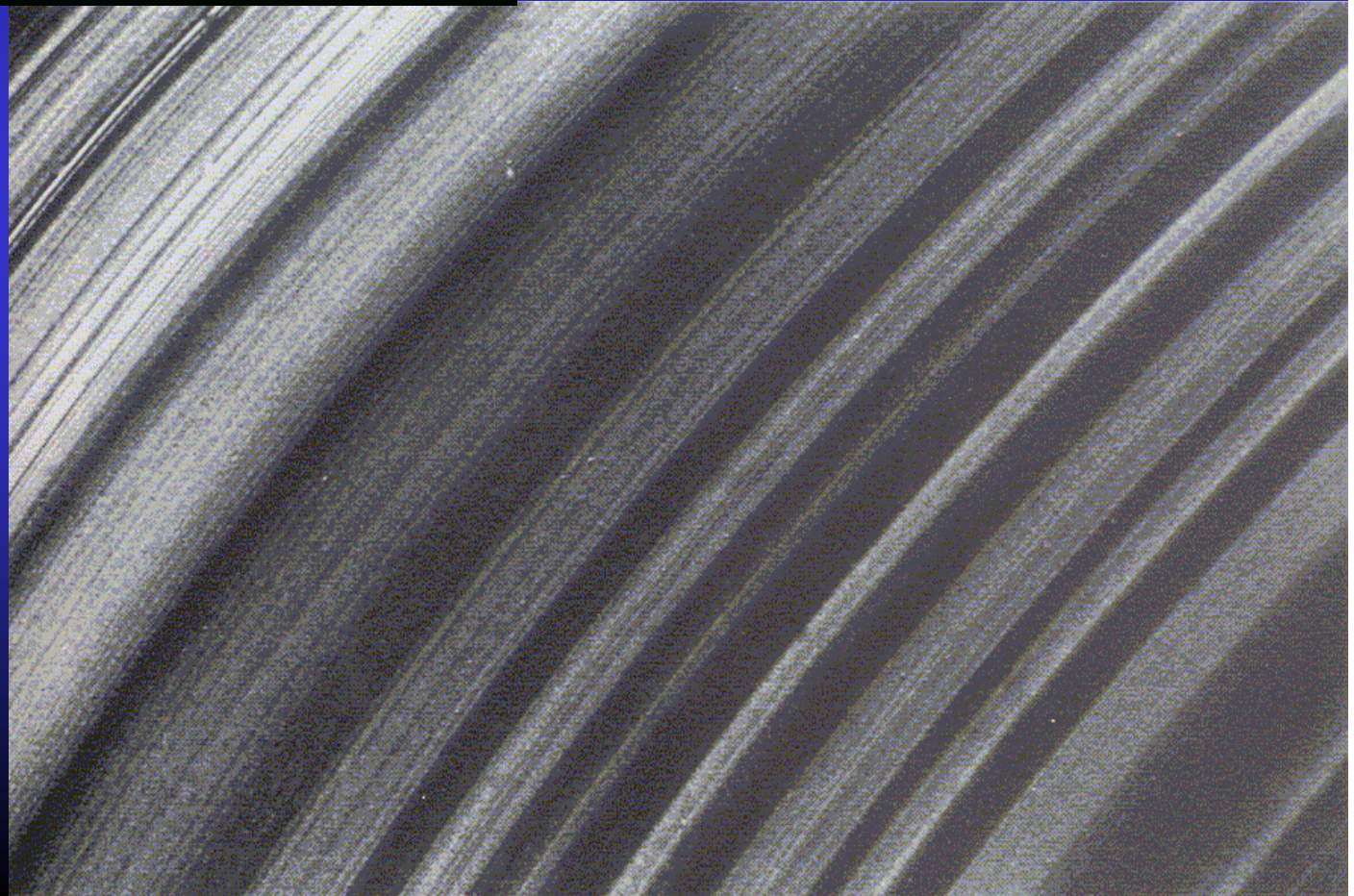


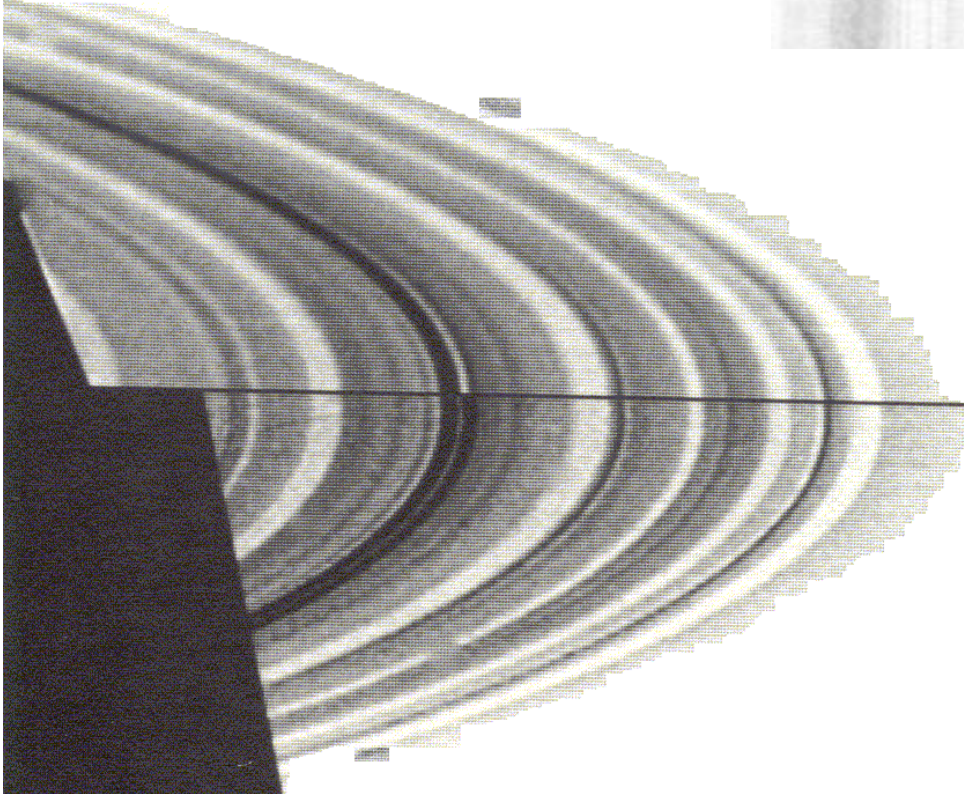
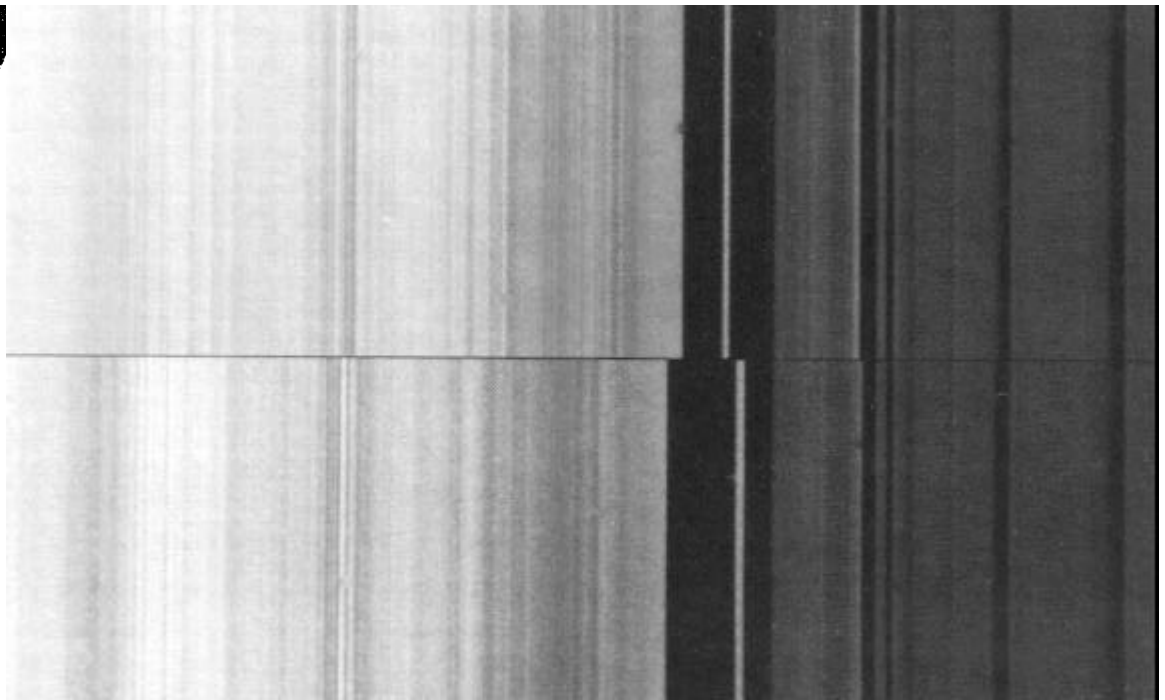
**Fine radial
«irregular»
structure**

**«Record
grooves»**

-

**Empty
gaps**



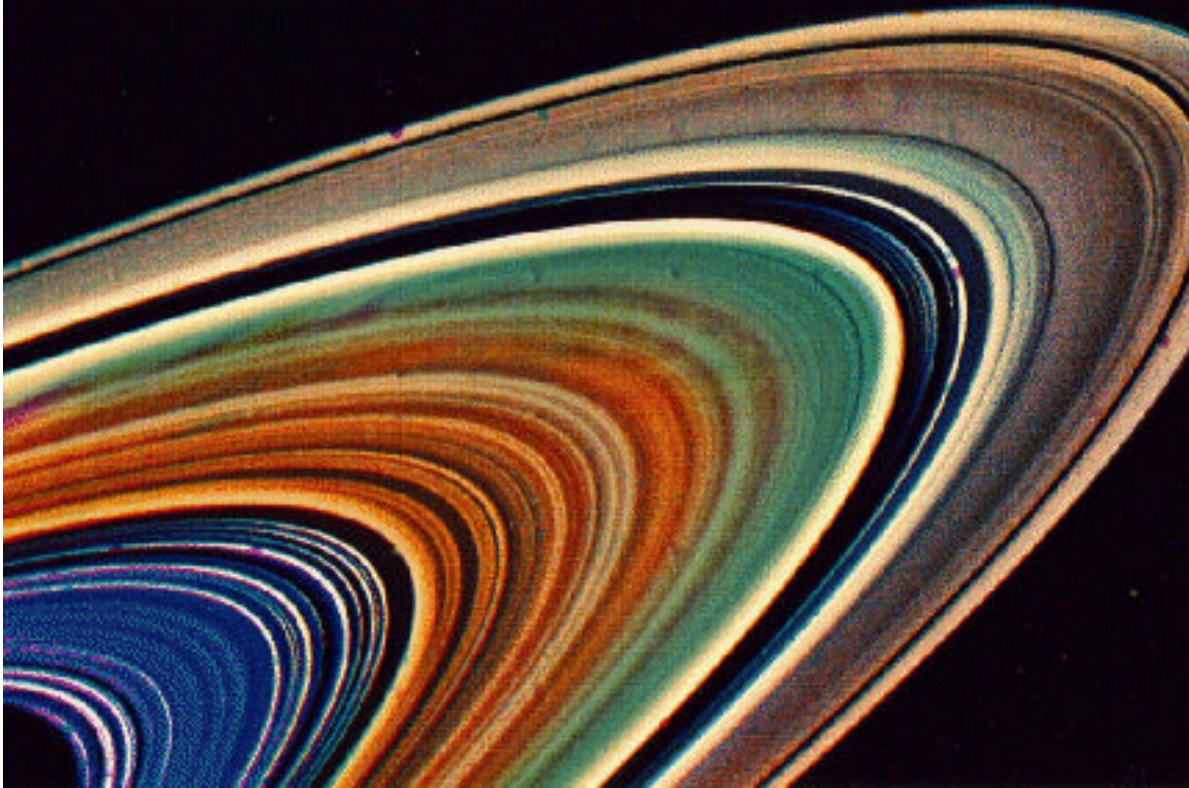


- Azimuthally variable
- Some very regular sharp-edged, elliptical
- Moonlet + incomplete rings (arcs)



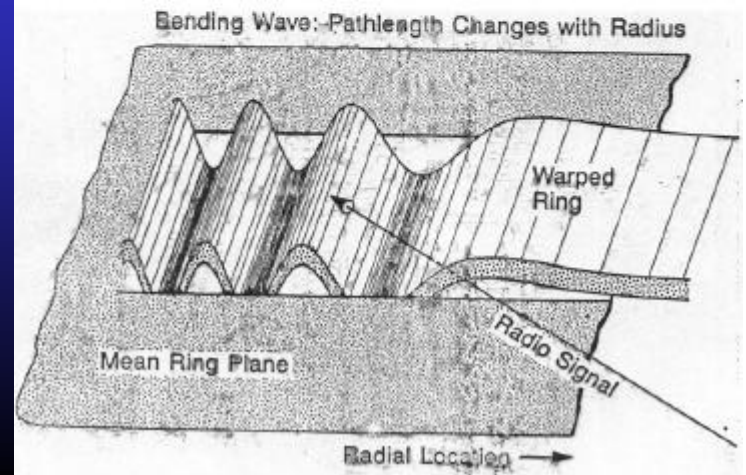
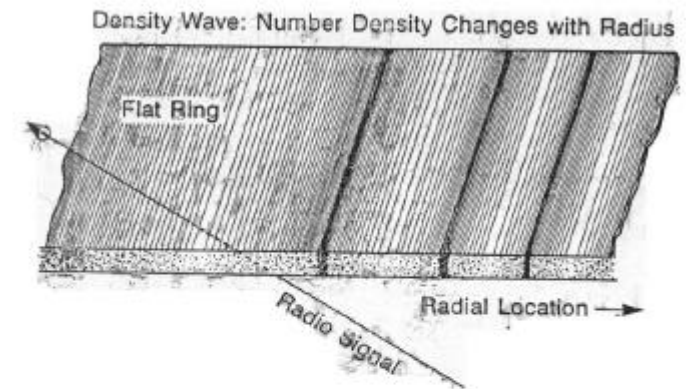
1 t

Regional and local variations in particle colors

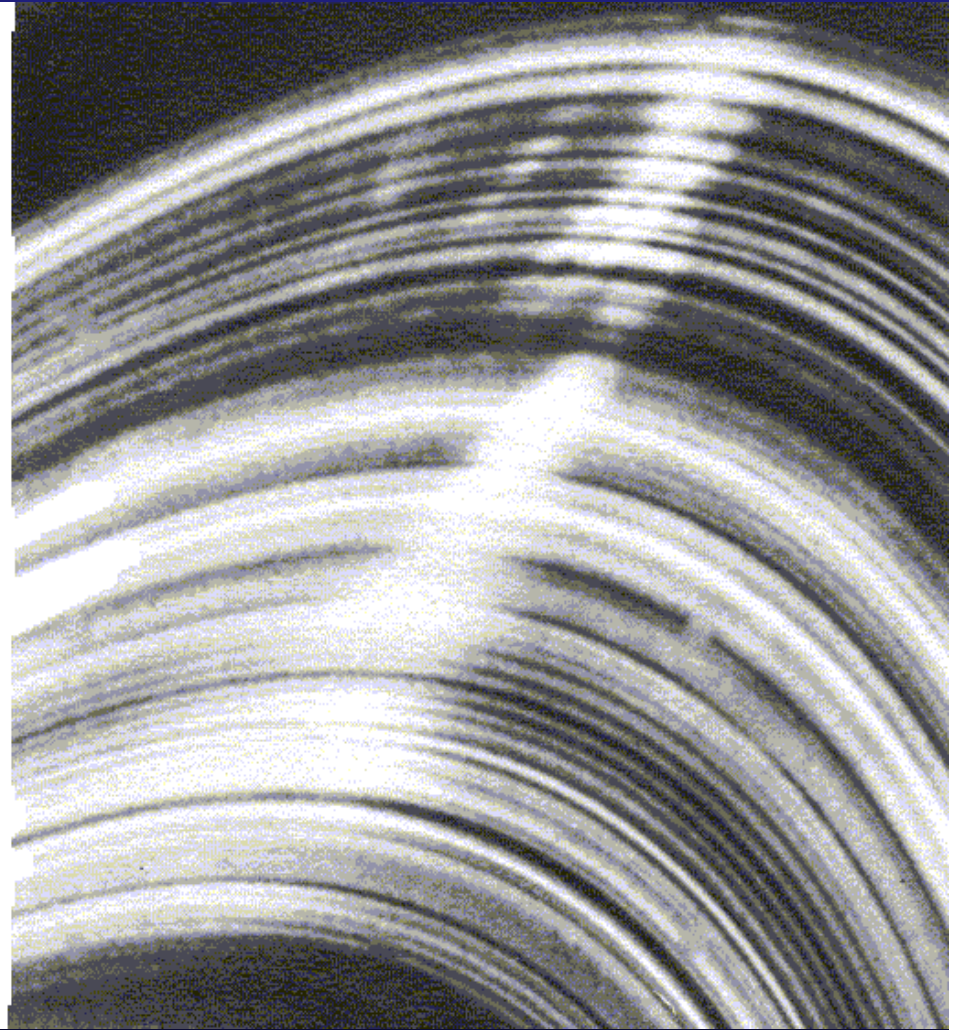
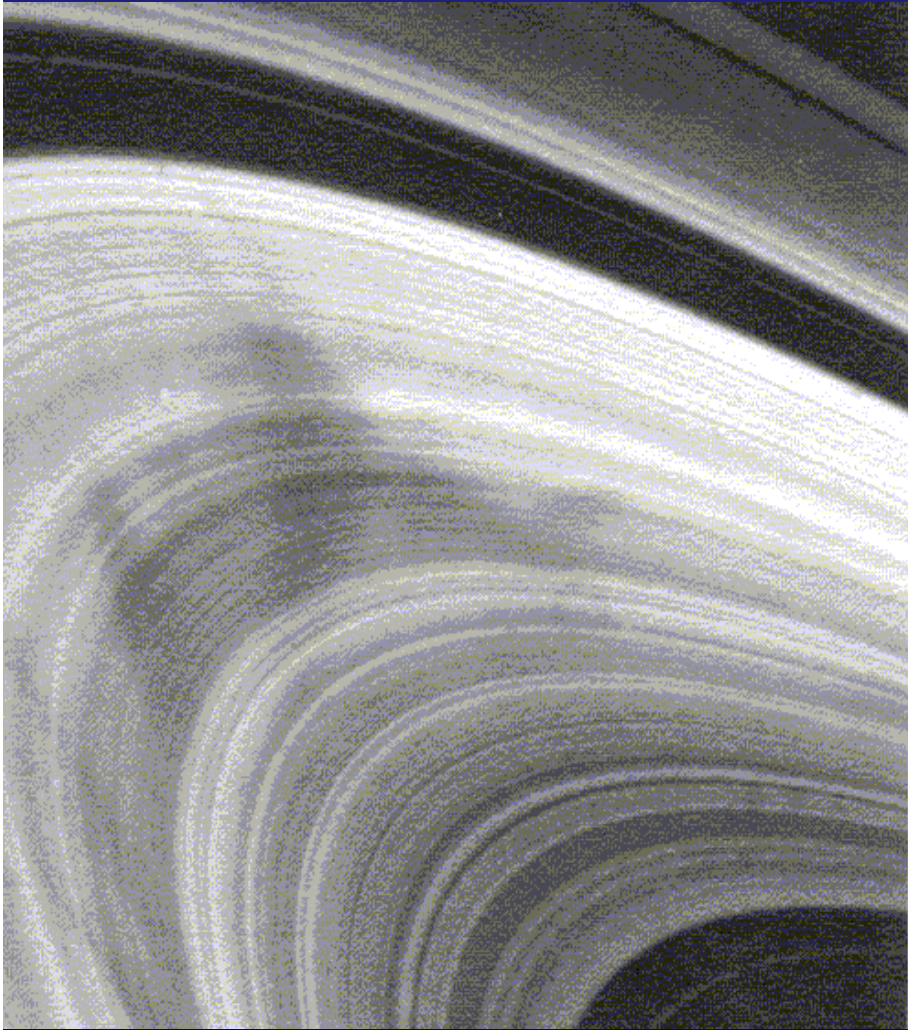


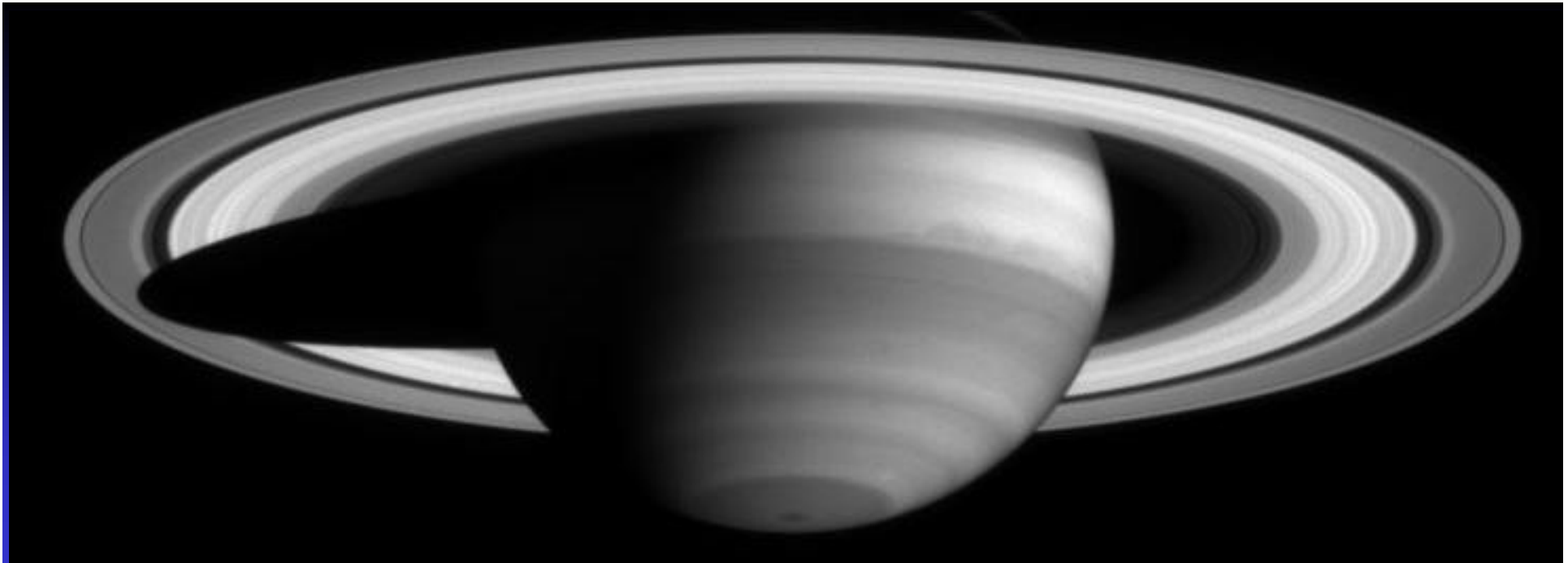
Spiral density waves and bending waves

Radio Occultation as a Probe of
Density & Bending Waves

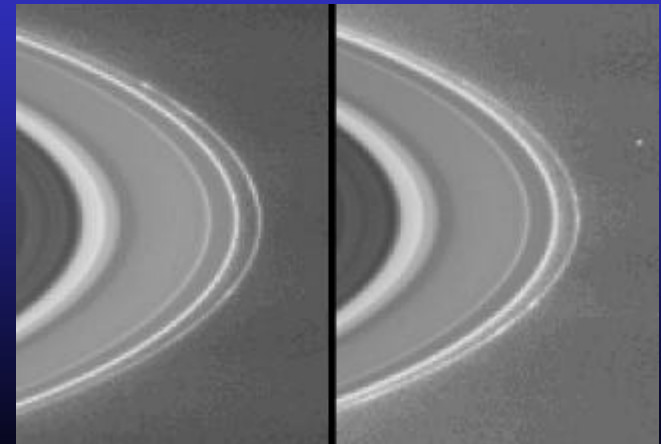
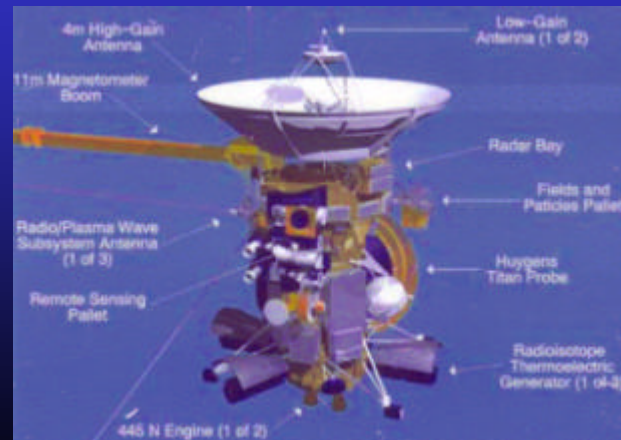


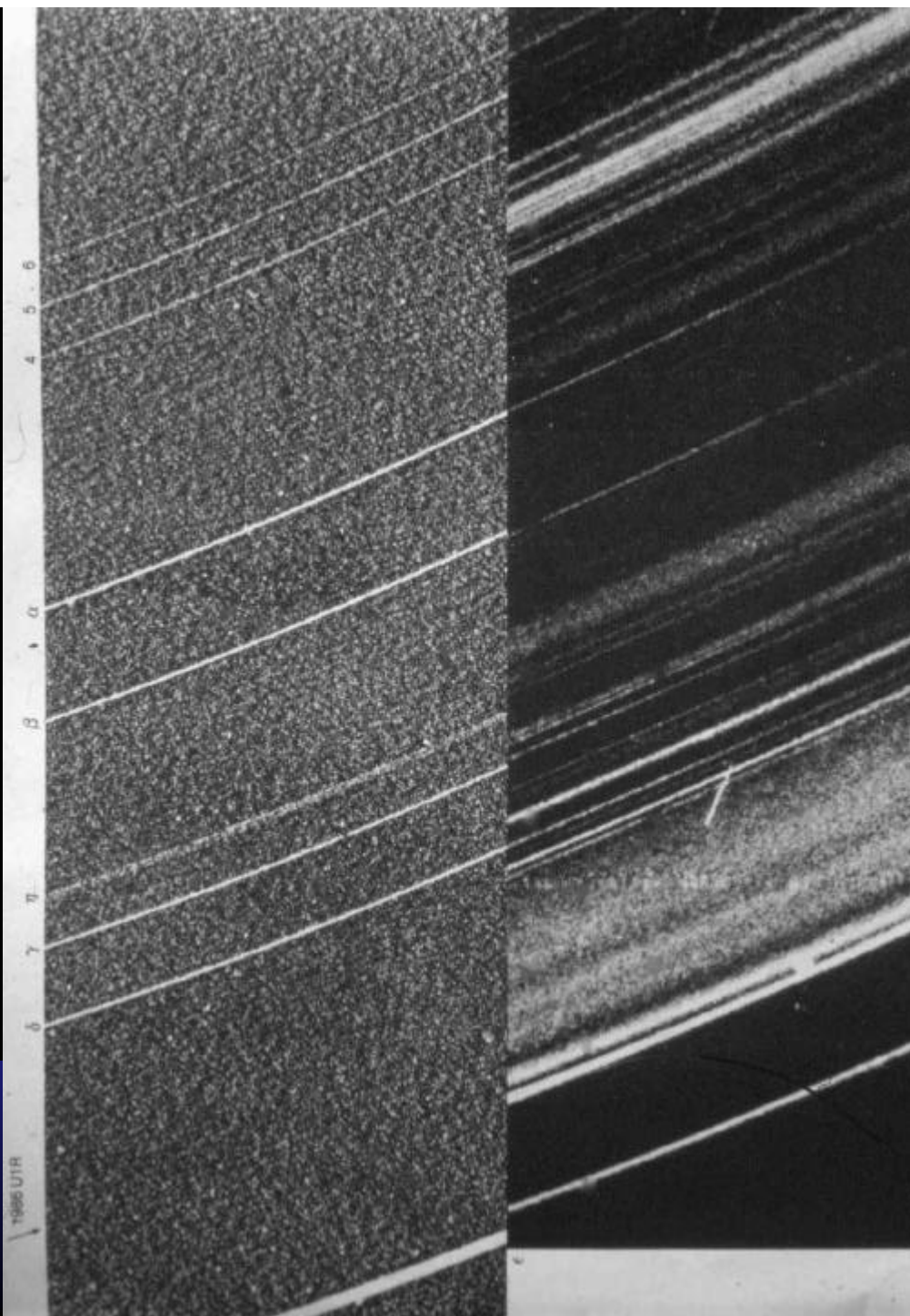
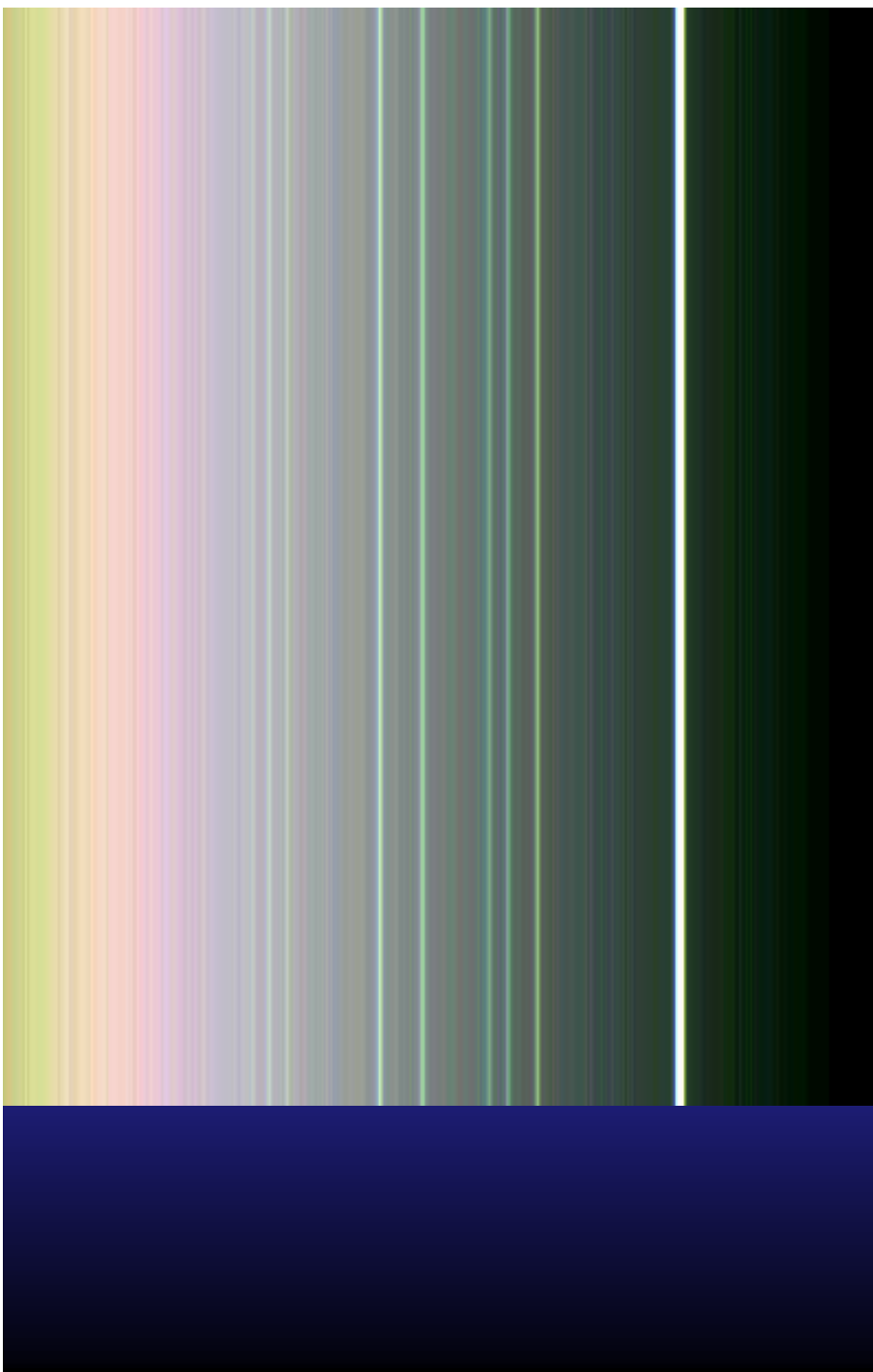
«spokes»

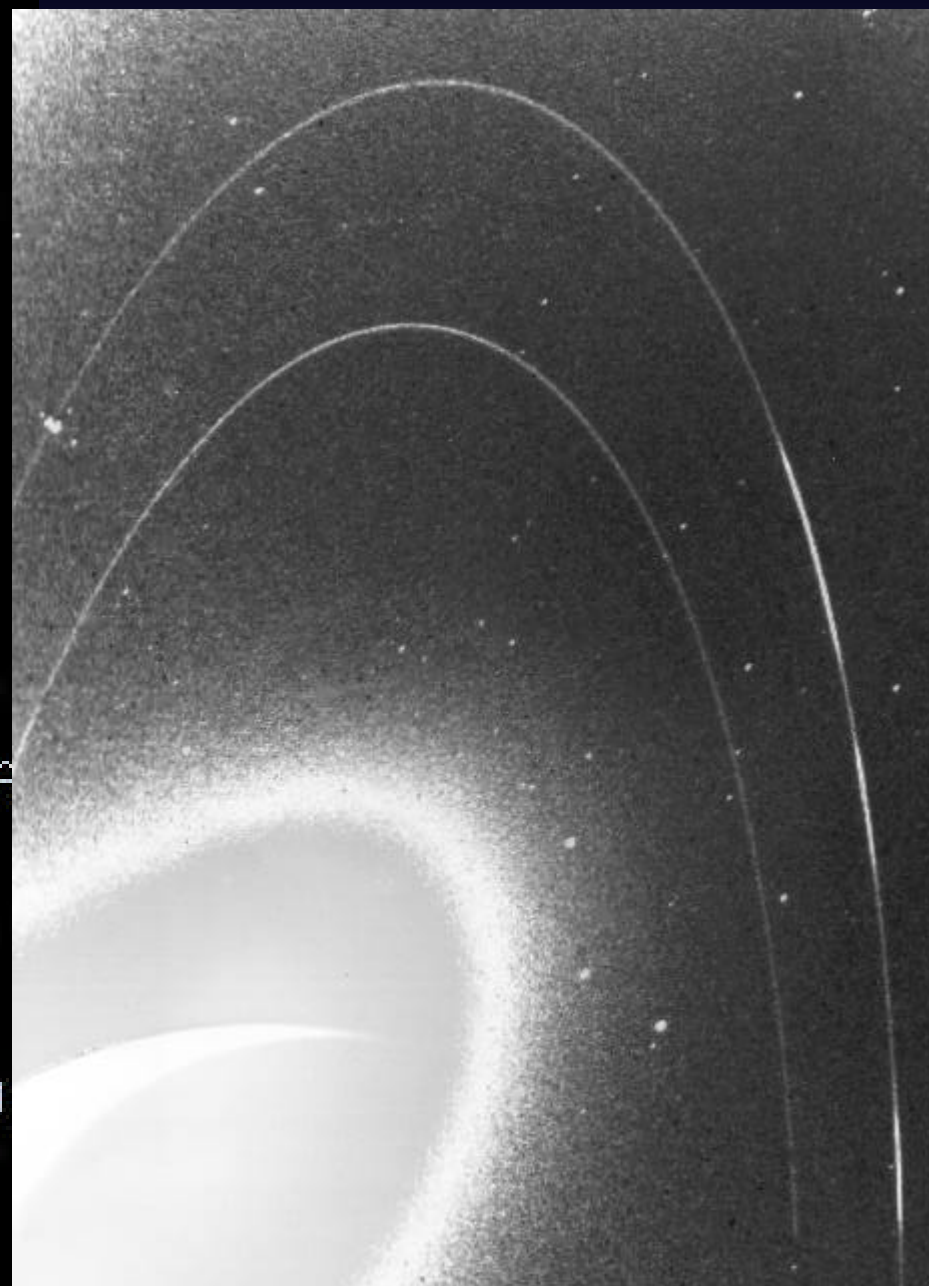
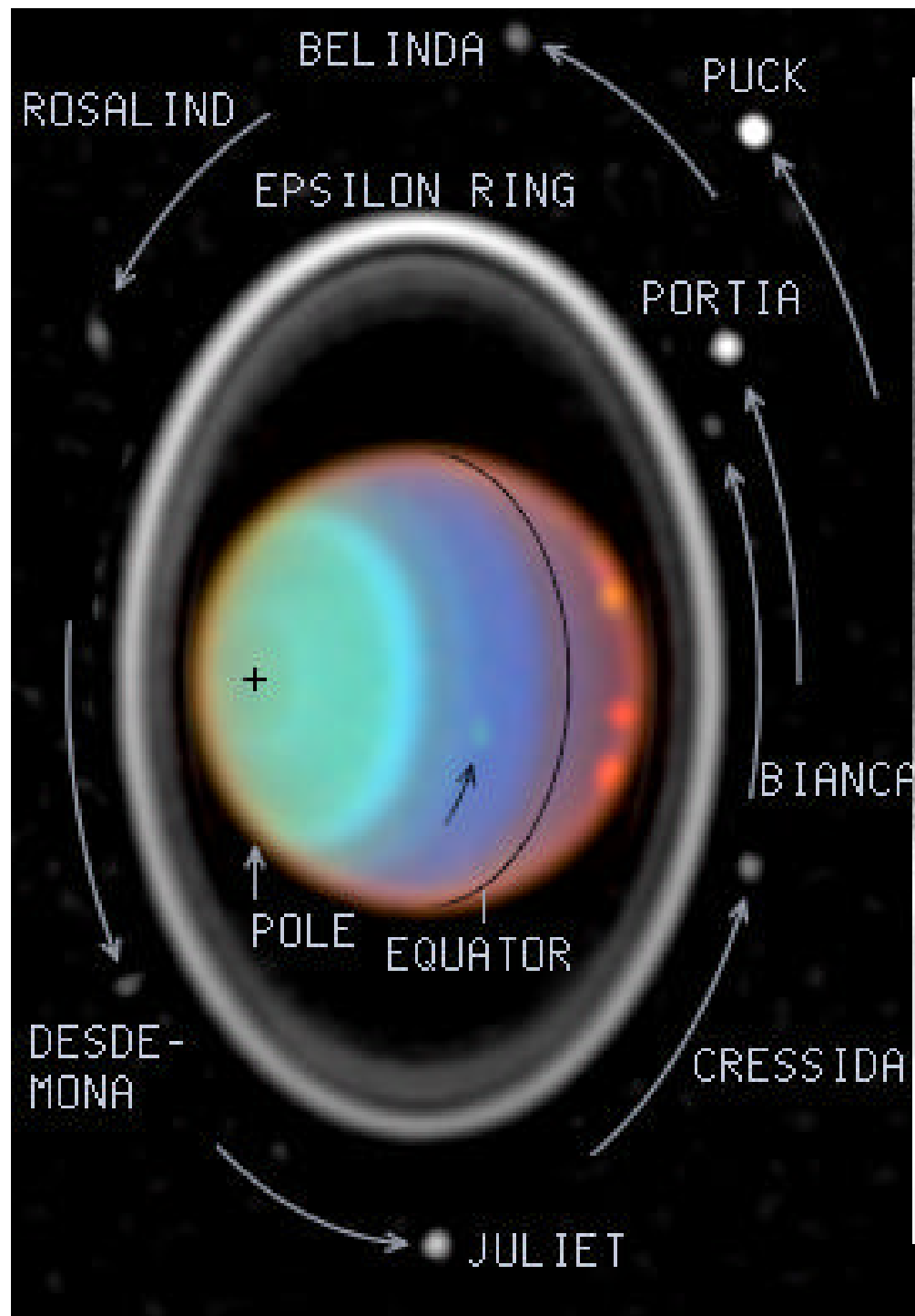


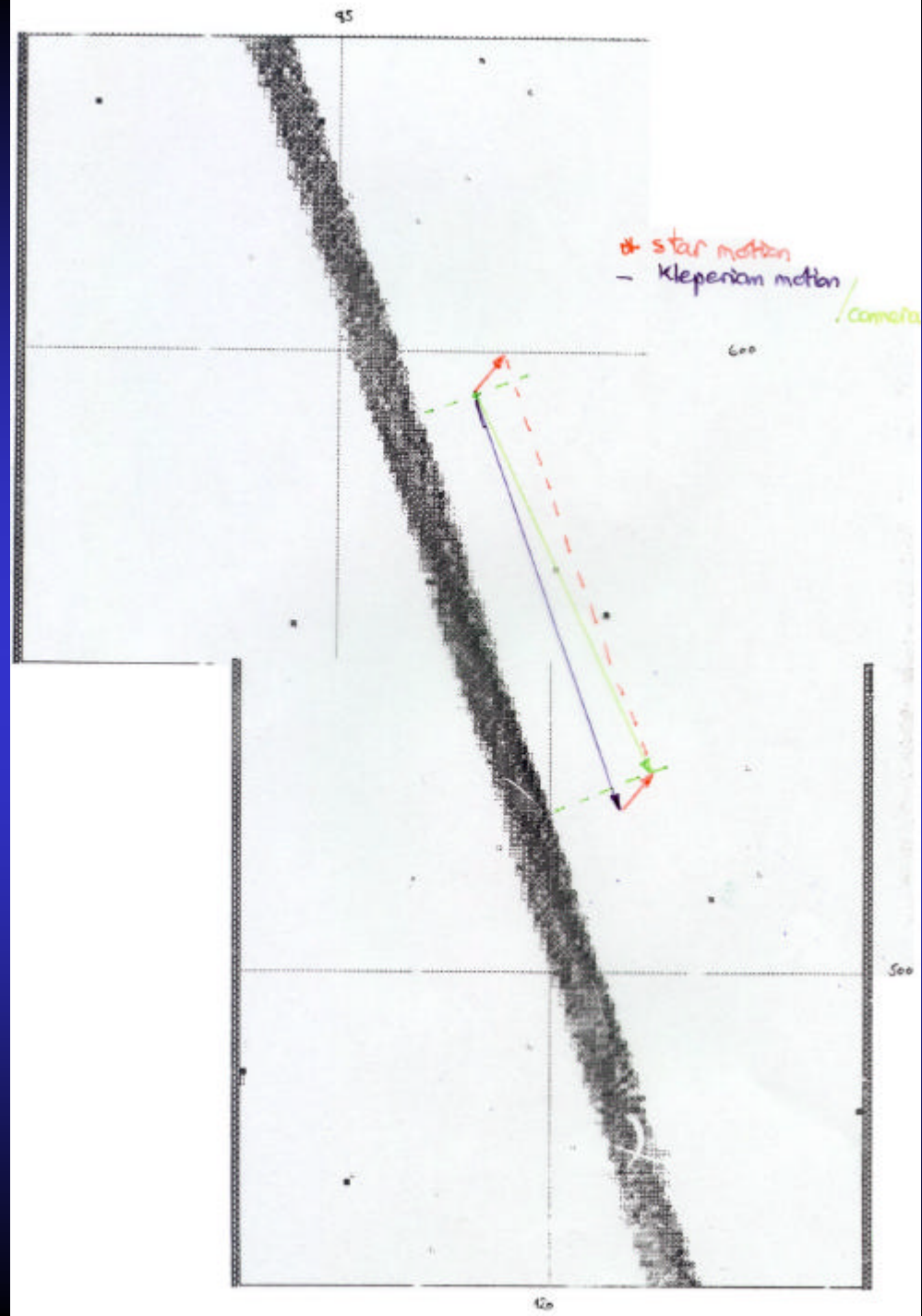


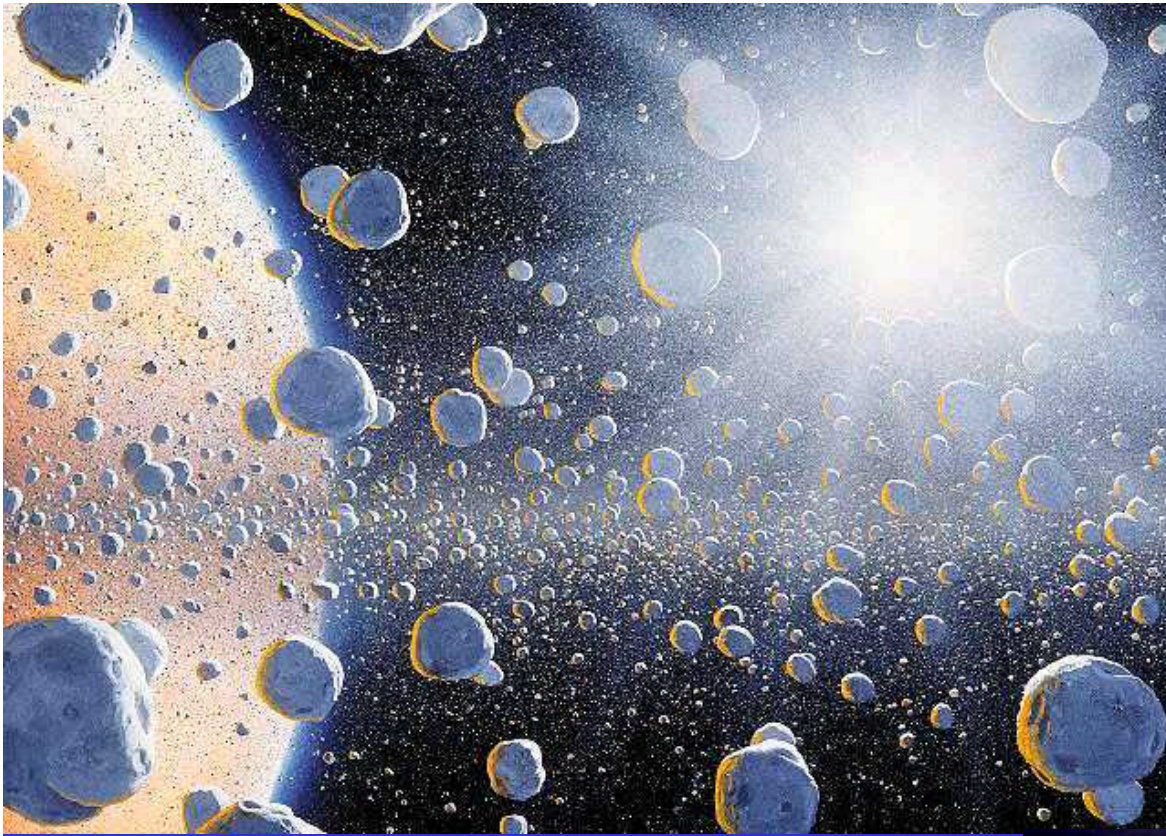
**Failure of the scan platform on August 26, 1981:
loss of data, but « repaired » before Uranus encounter
... and Cassini**



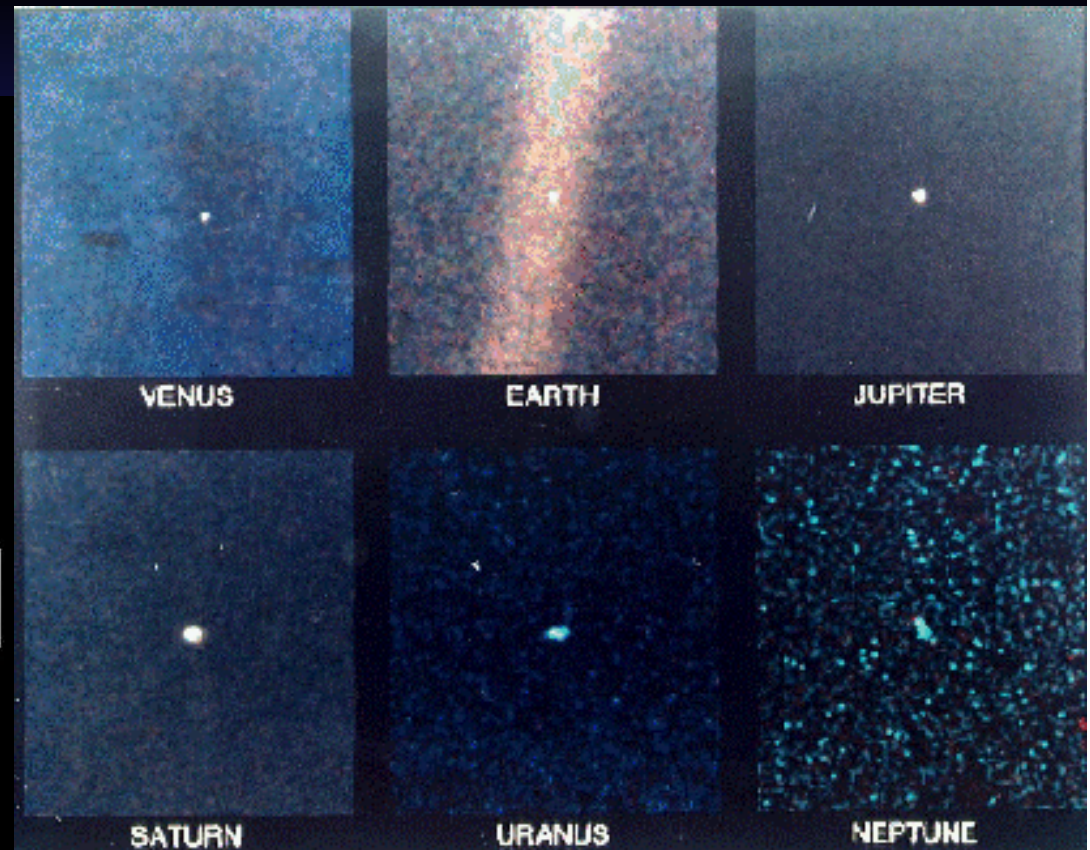
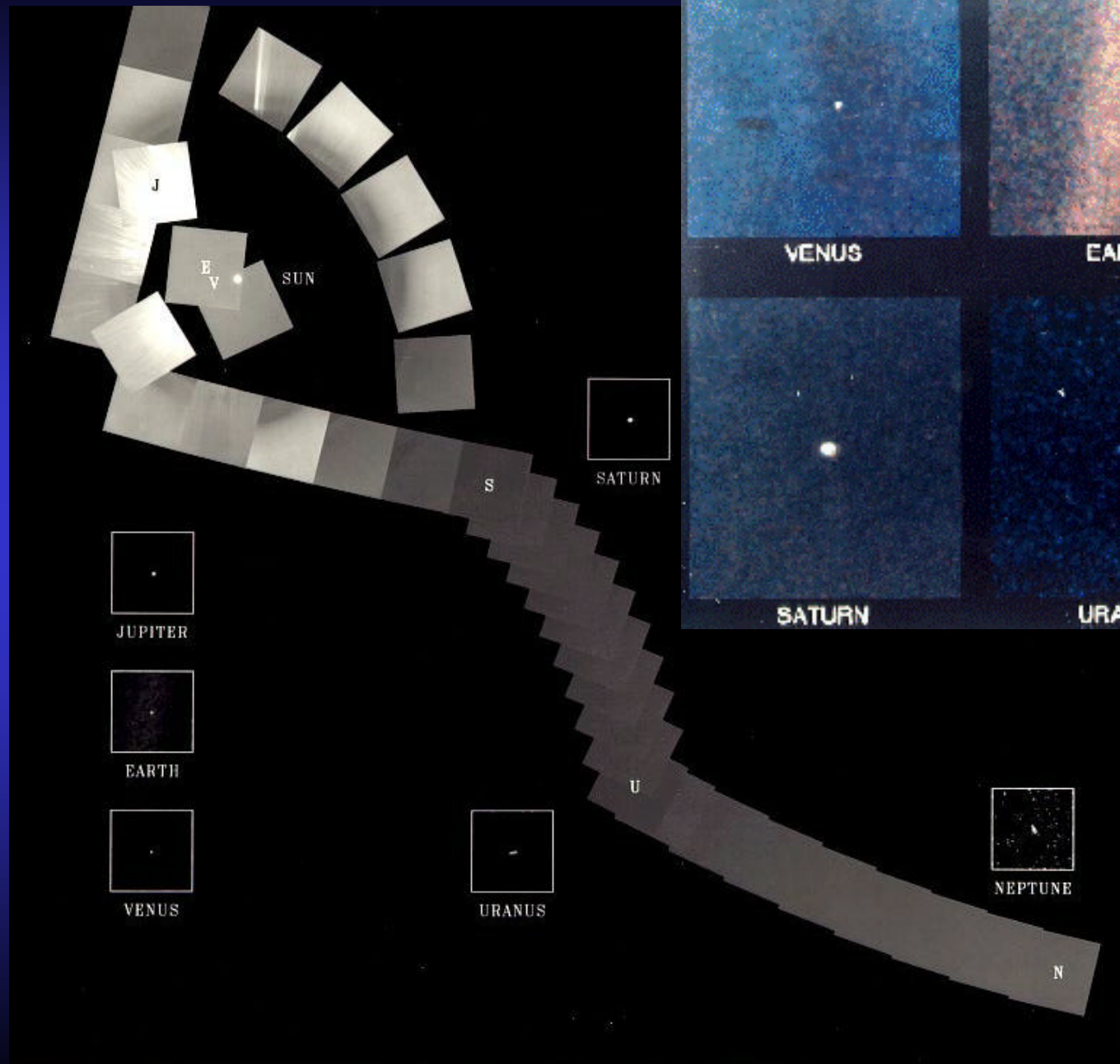








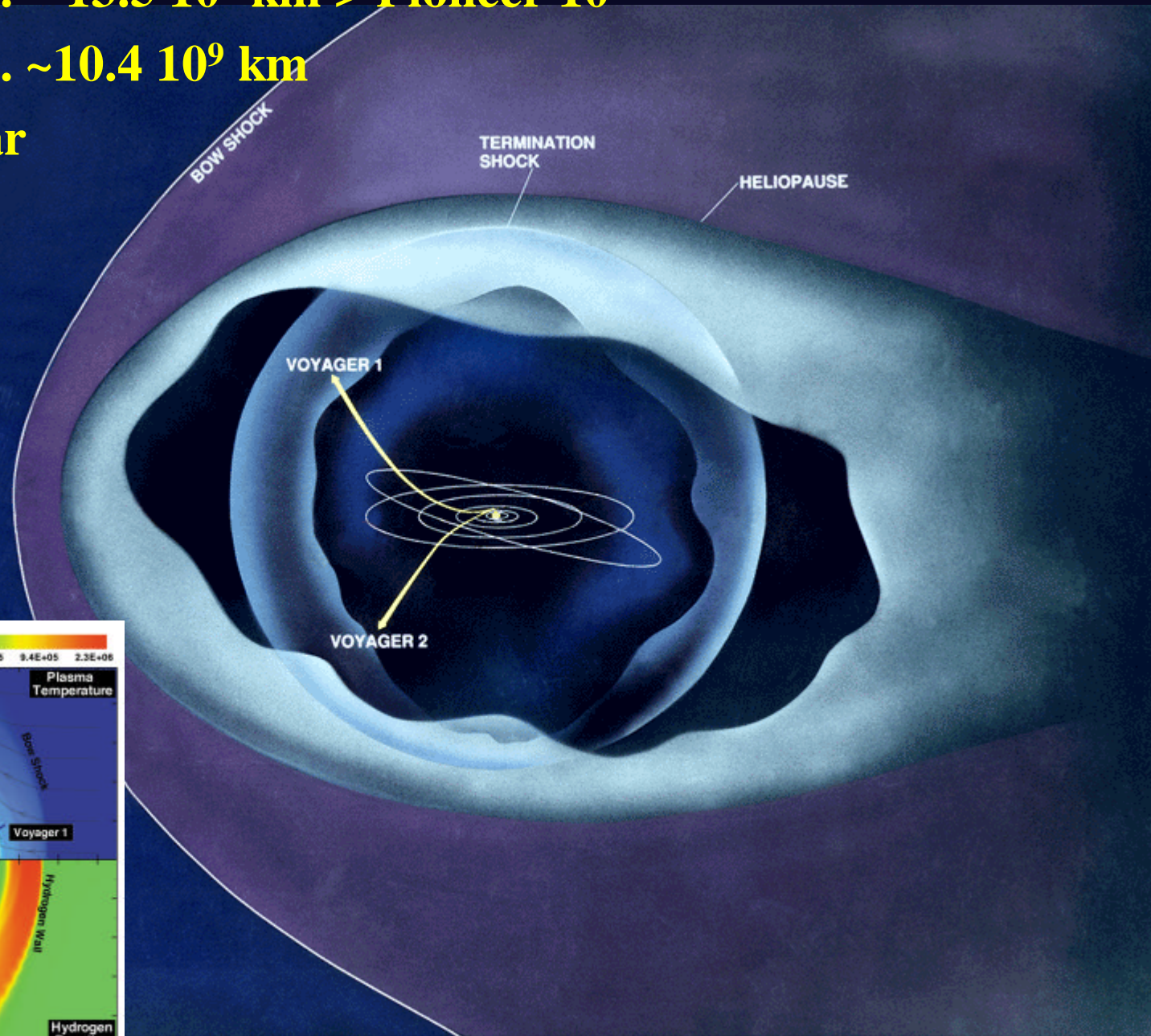
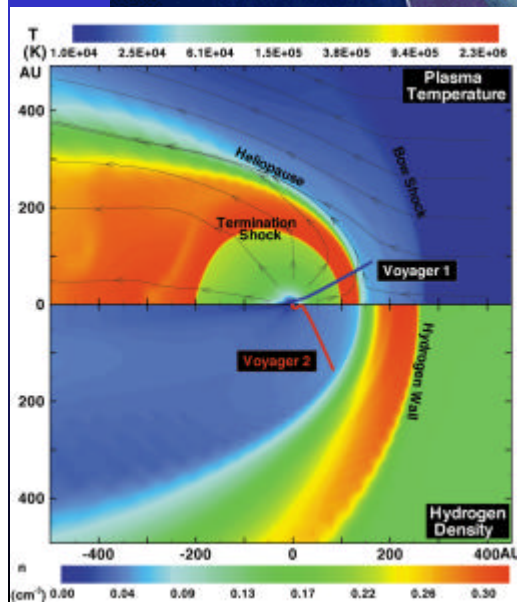


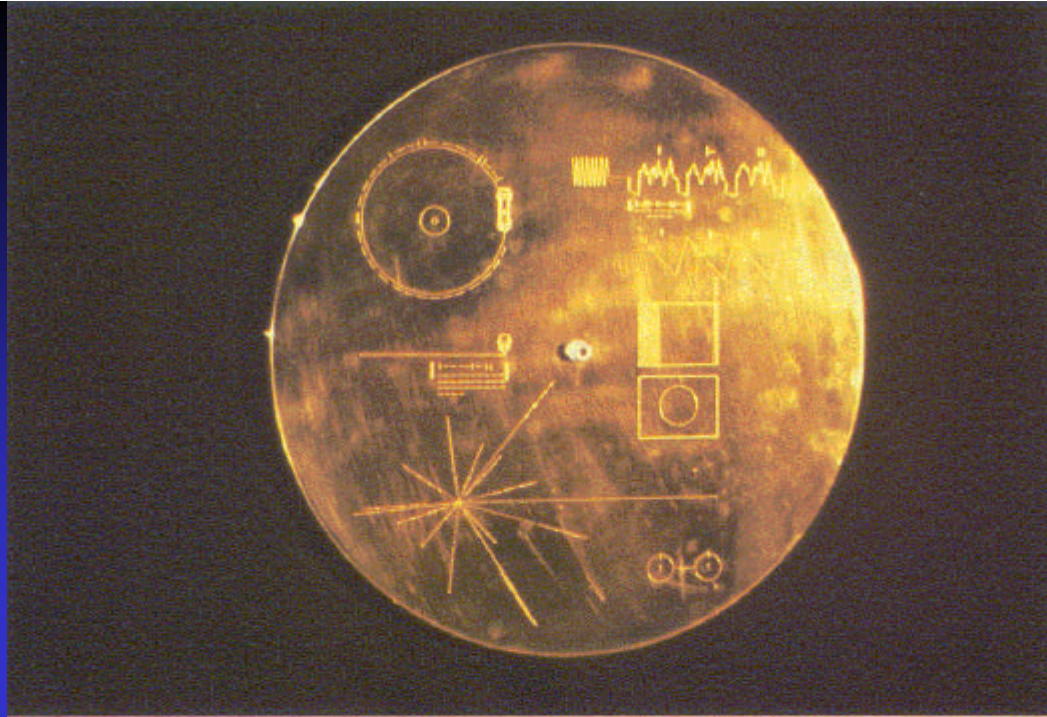


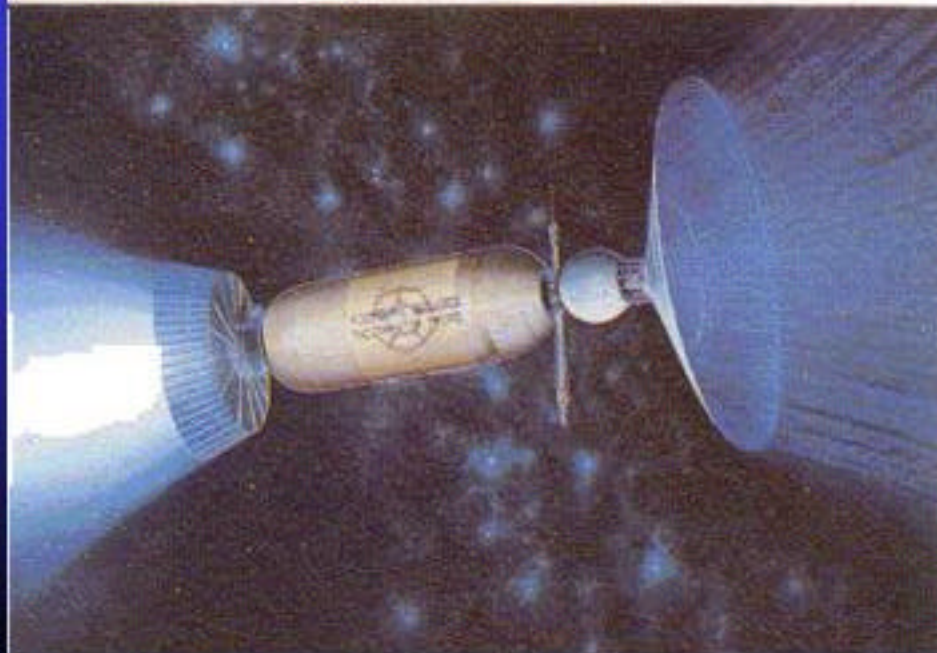
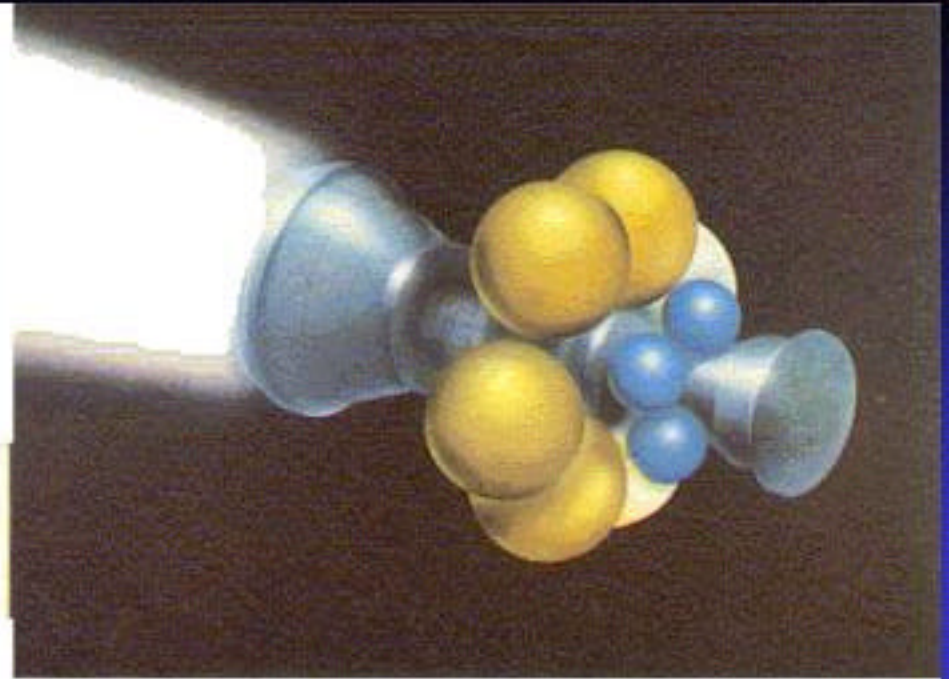
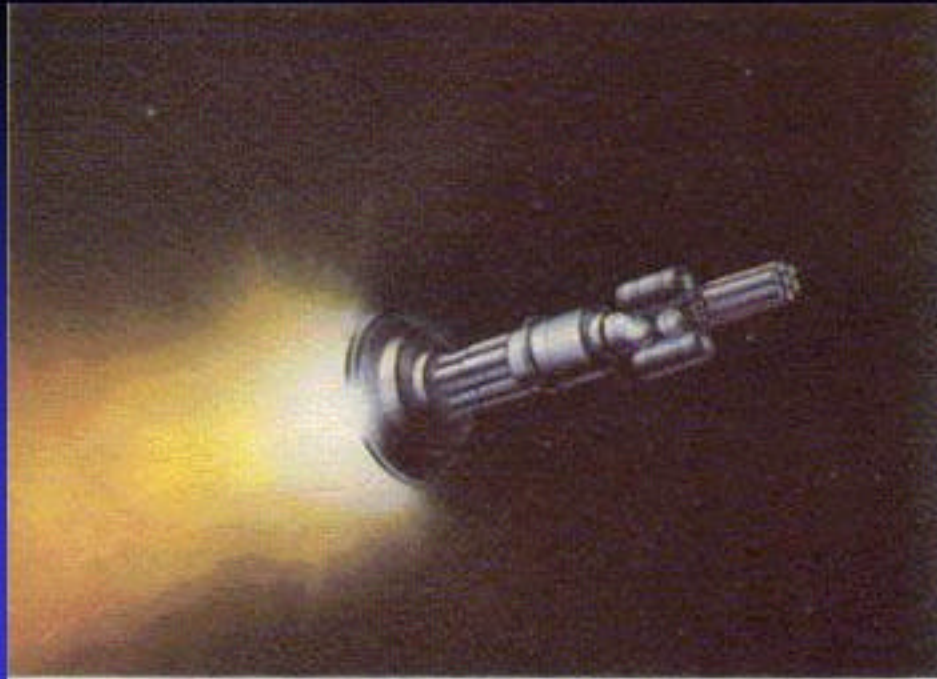
V1: > 90 a.u. ~ $13.5 \cdot 10^9$ km > Pioneer 10

V2: > 70 a.u. ~ $10.4 \cdot 10^9$ km

3.6 a.u. / year







Futur?

3.9 millions years .. or 2 hours?

