Planetary Rings and the Cassini Mission to Saturn

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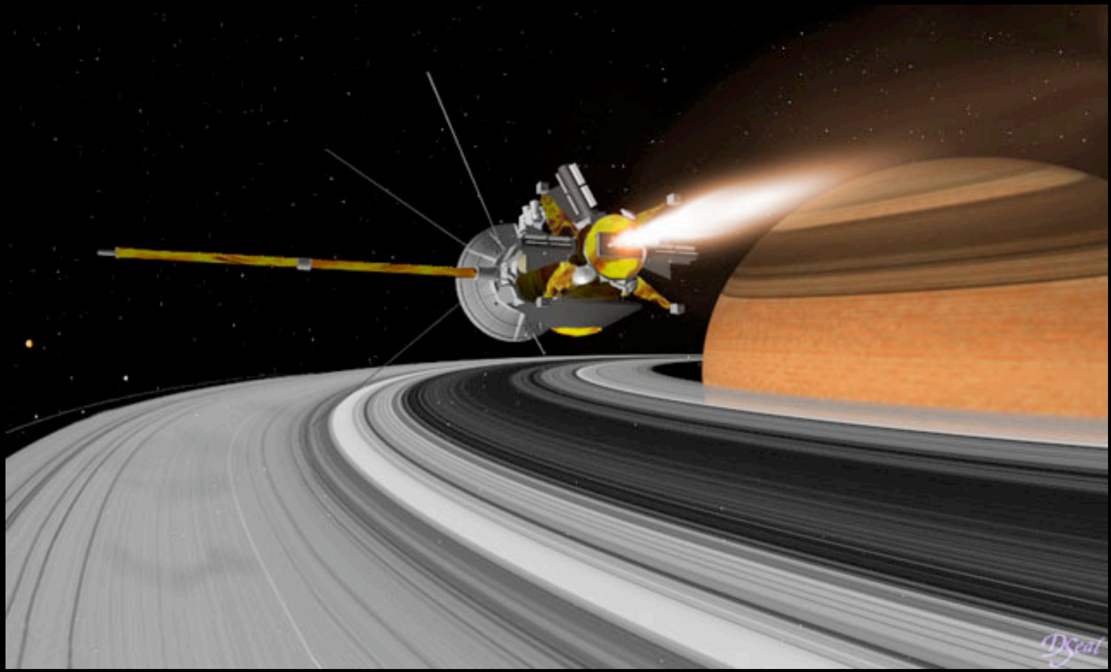
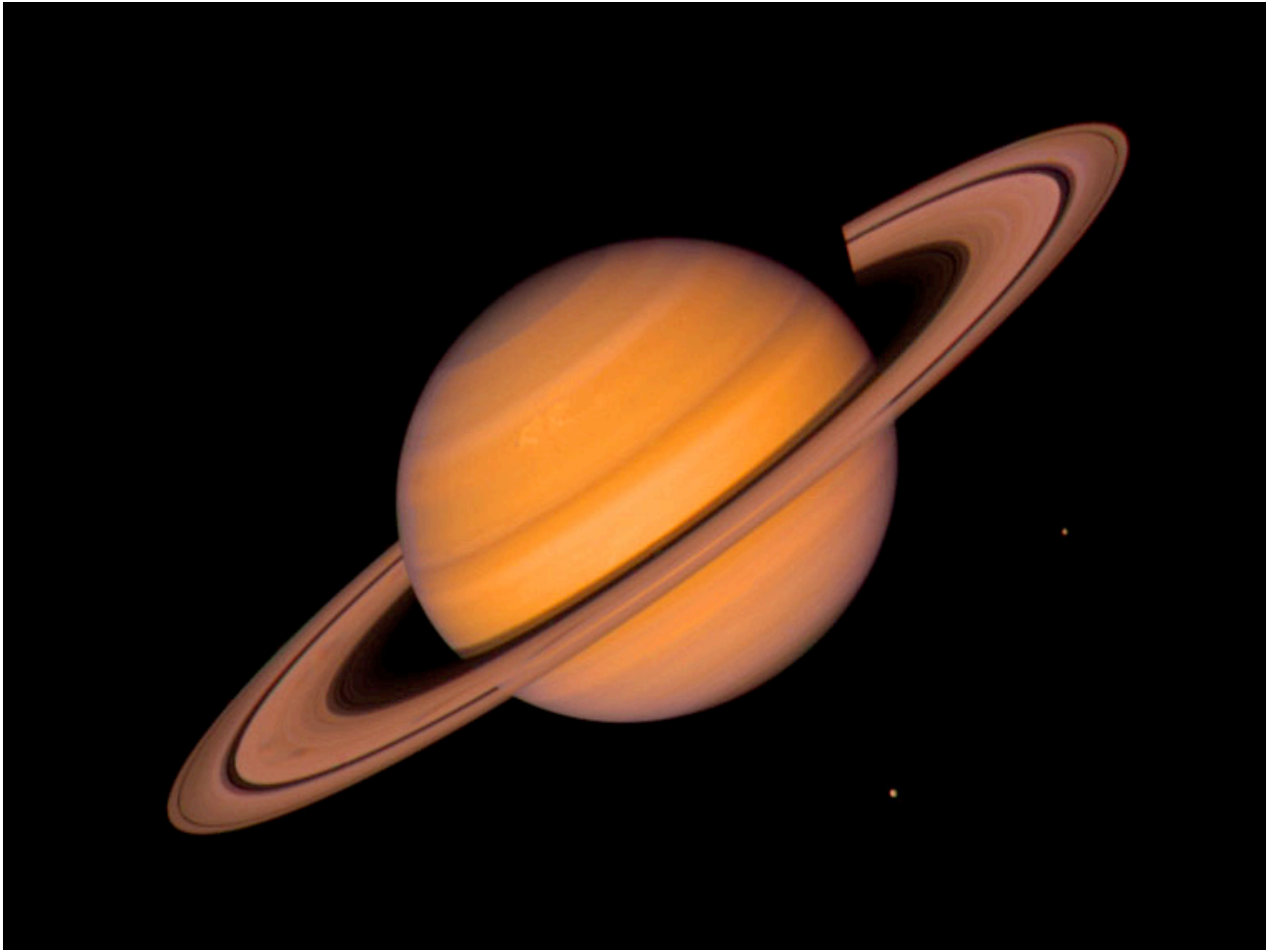
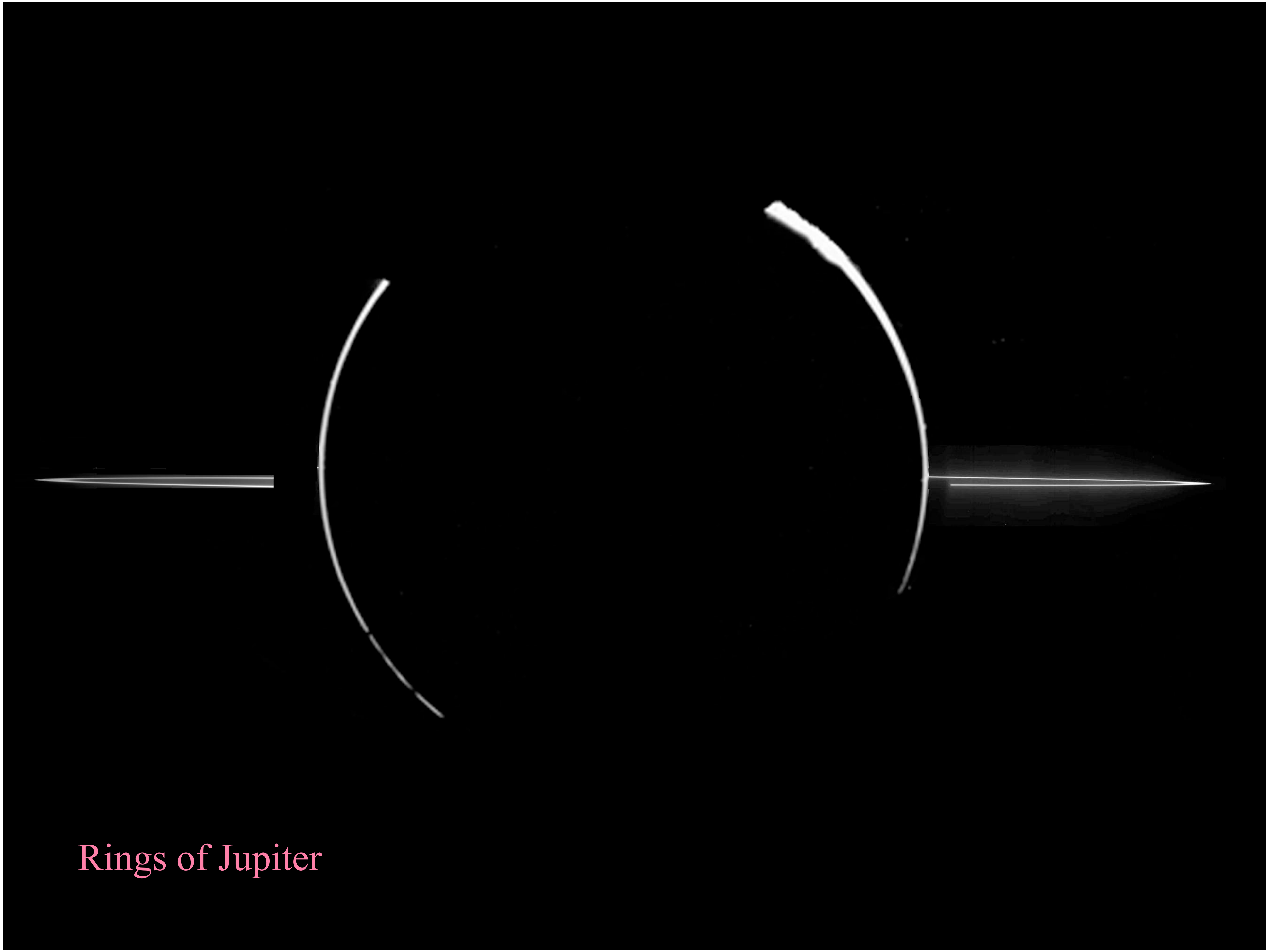


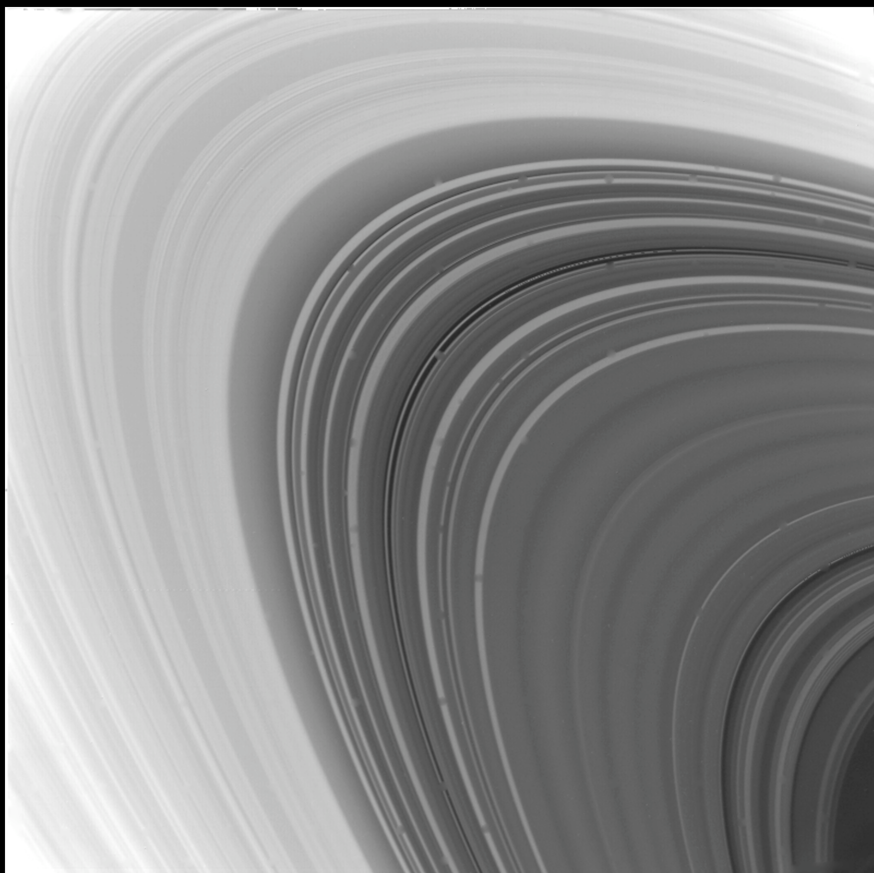
Outline

- Inventory of planetary rings
- What are rings, and how do they work?
- The Cassini mission to Saturn
- Latest results from Cassini at Jupiter

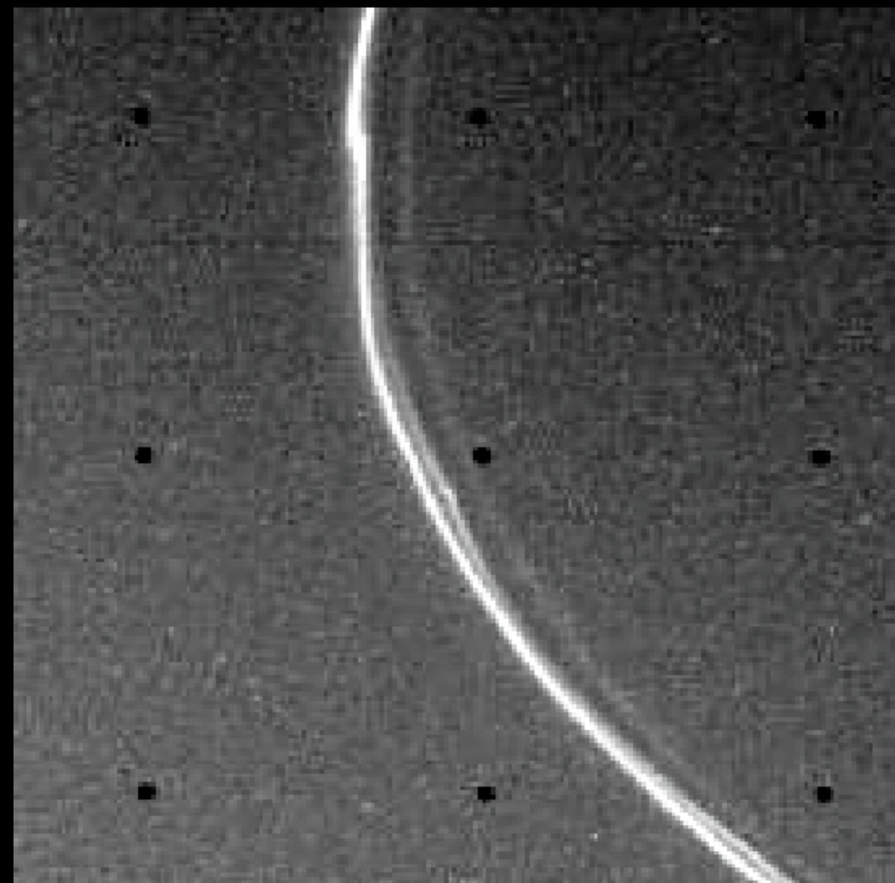



Rings of Jupiter

Features in Saturn's Rings



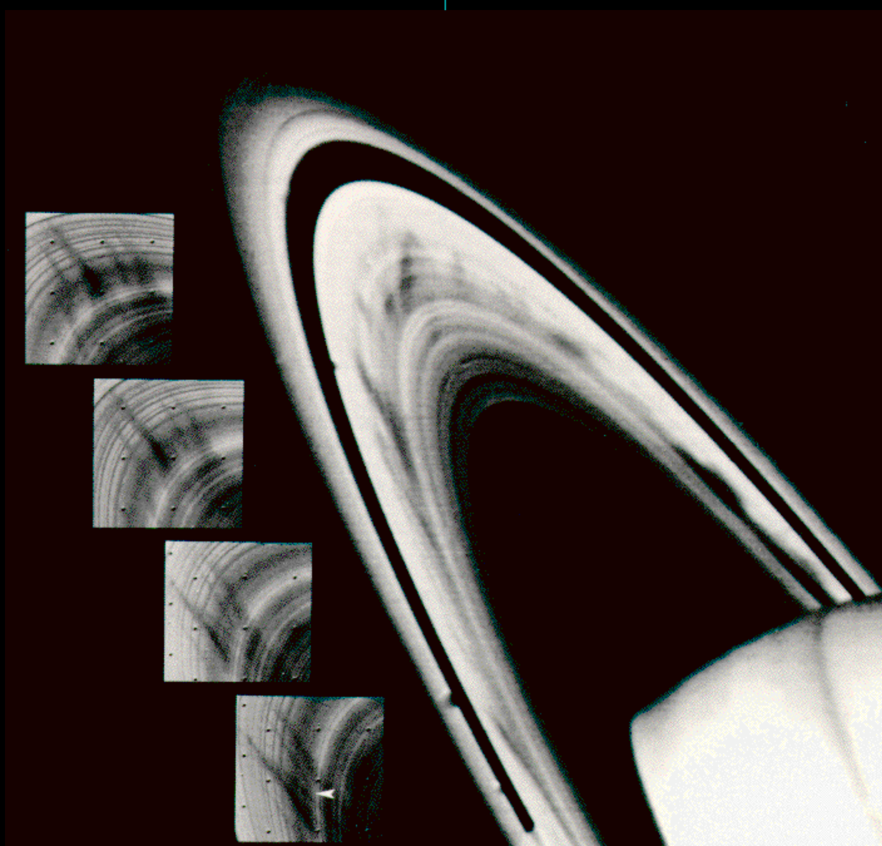
Rings within rings...

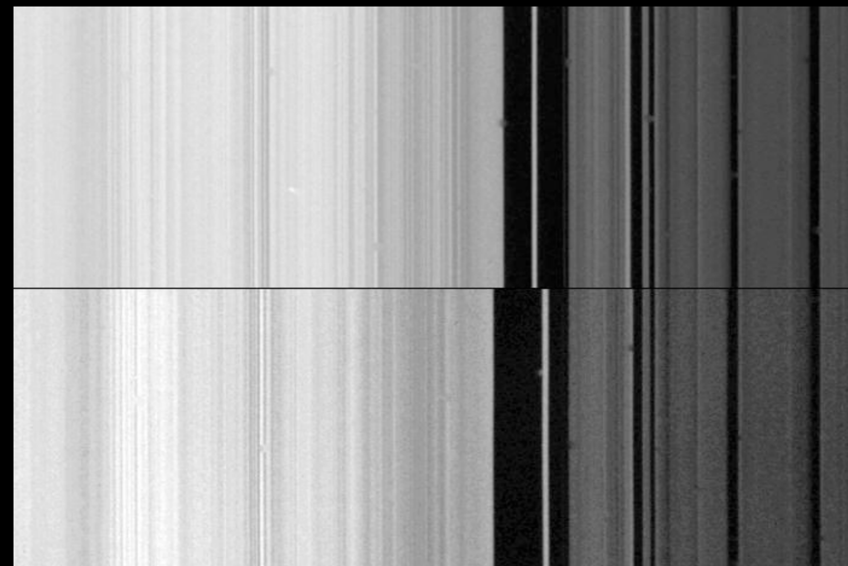


Twisted, braided rings...

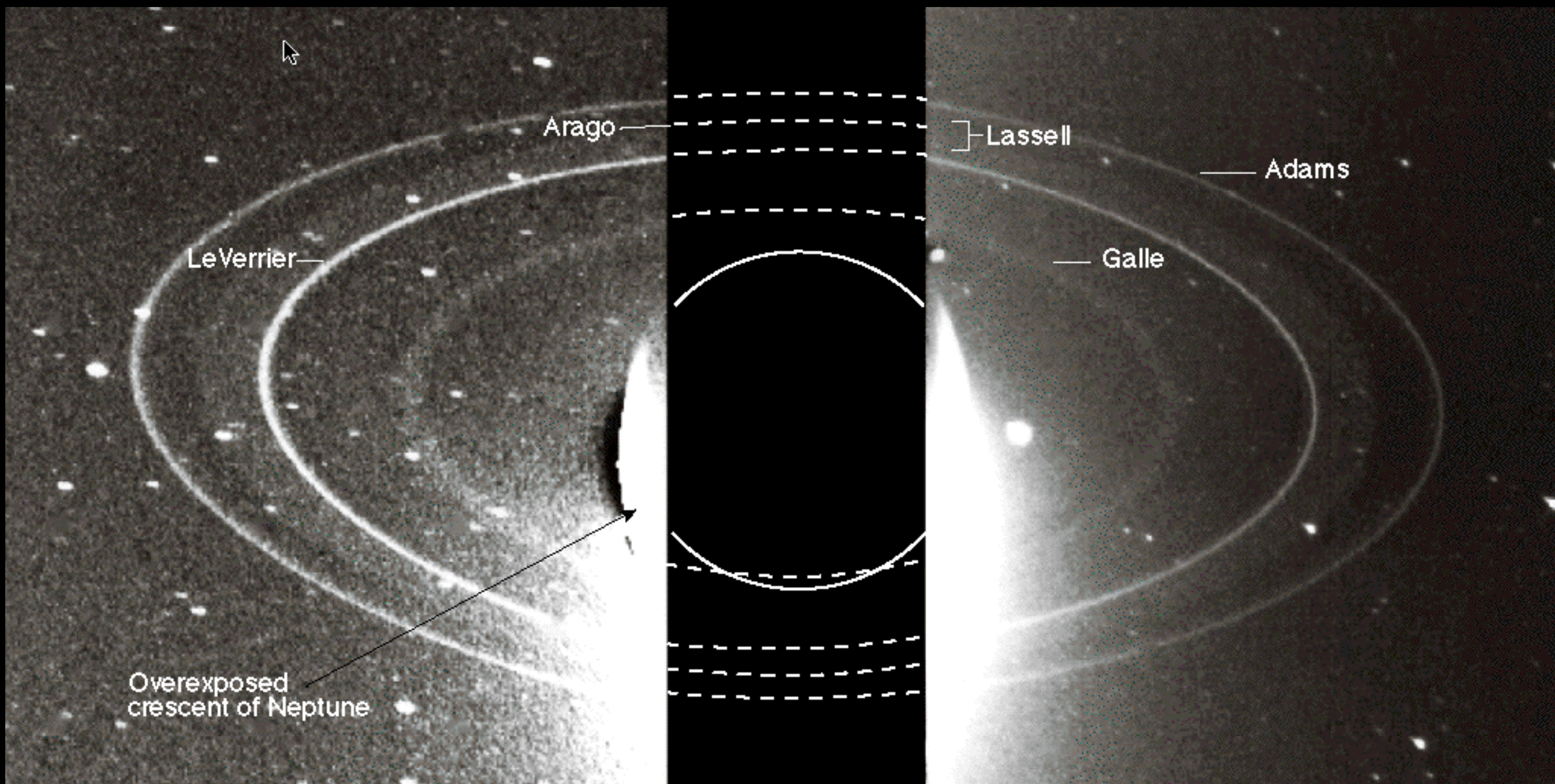
More Features in Saturn's Rings

'Spokes' appearing and disappearing

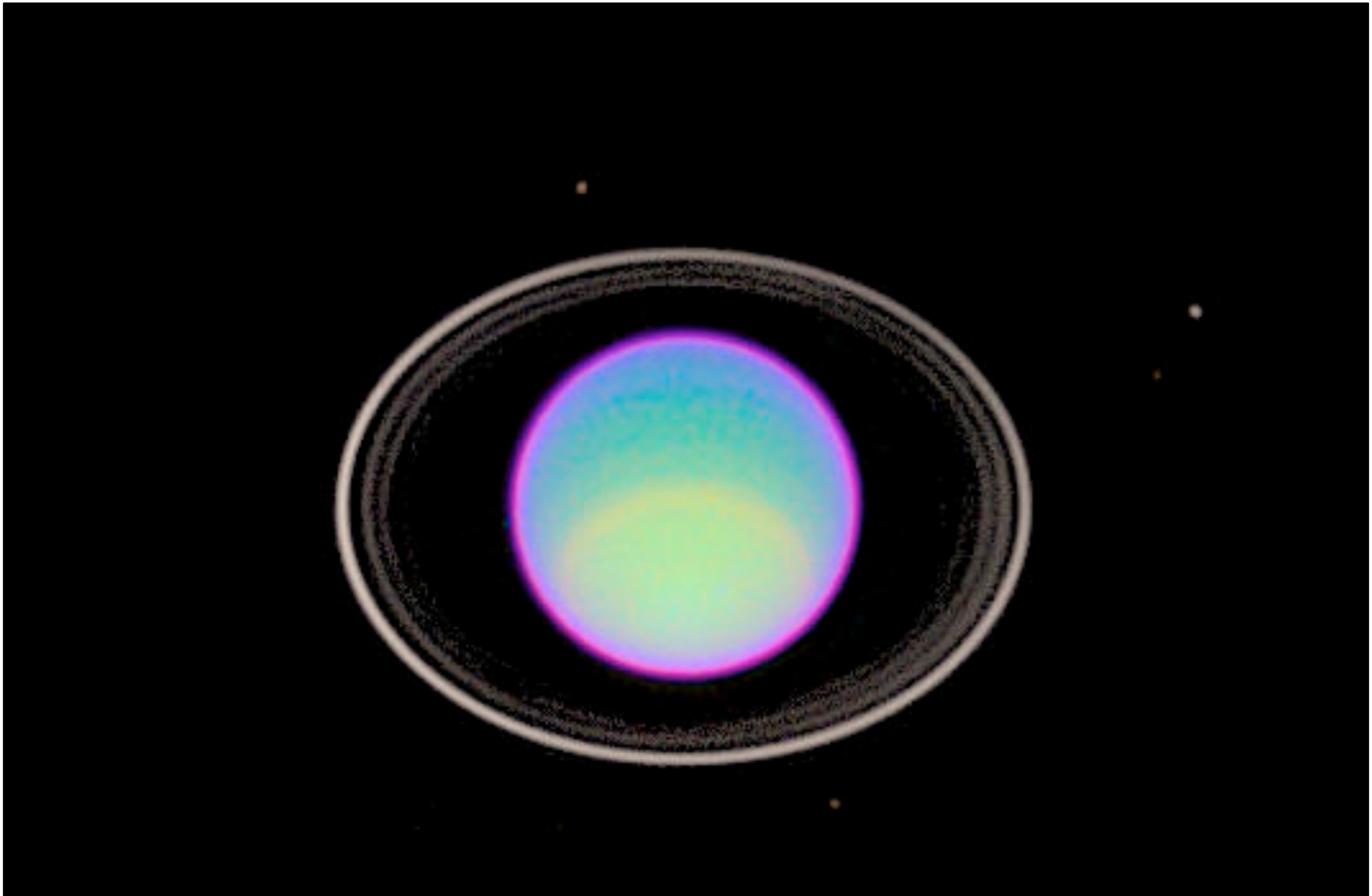




Symmetry and Asymmetry



Rings of Neptune



Rings of Uranus

Ring Dynamics Equation Sheet (complete)

$$F = ma$$

$$F = GMm/r^2$$

A Brief Ring History

1. Satellite in orbit around planet is disrupted by collision

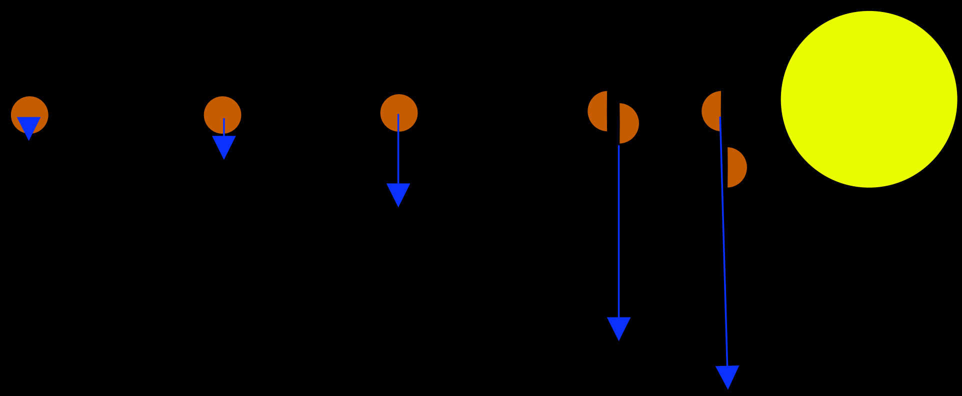
2. Collision triggers a cascade of collisions

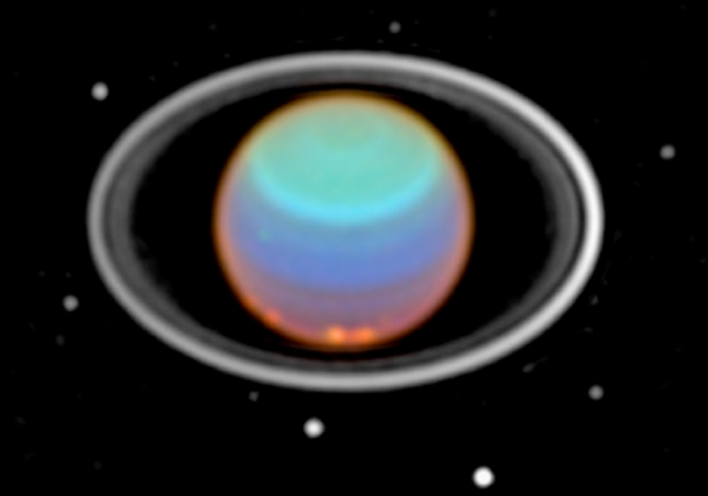
3. Small dust produces visible ring
   ‘If Saturn’s rings were made of bricks, they’d be invisible!’

Typical ring age: ~ 100 Myr ~ 1% age of solar system (short!)

Each ring particle is a small satellite in orbit around the planet

Tidal Forces in Rings

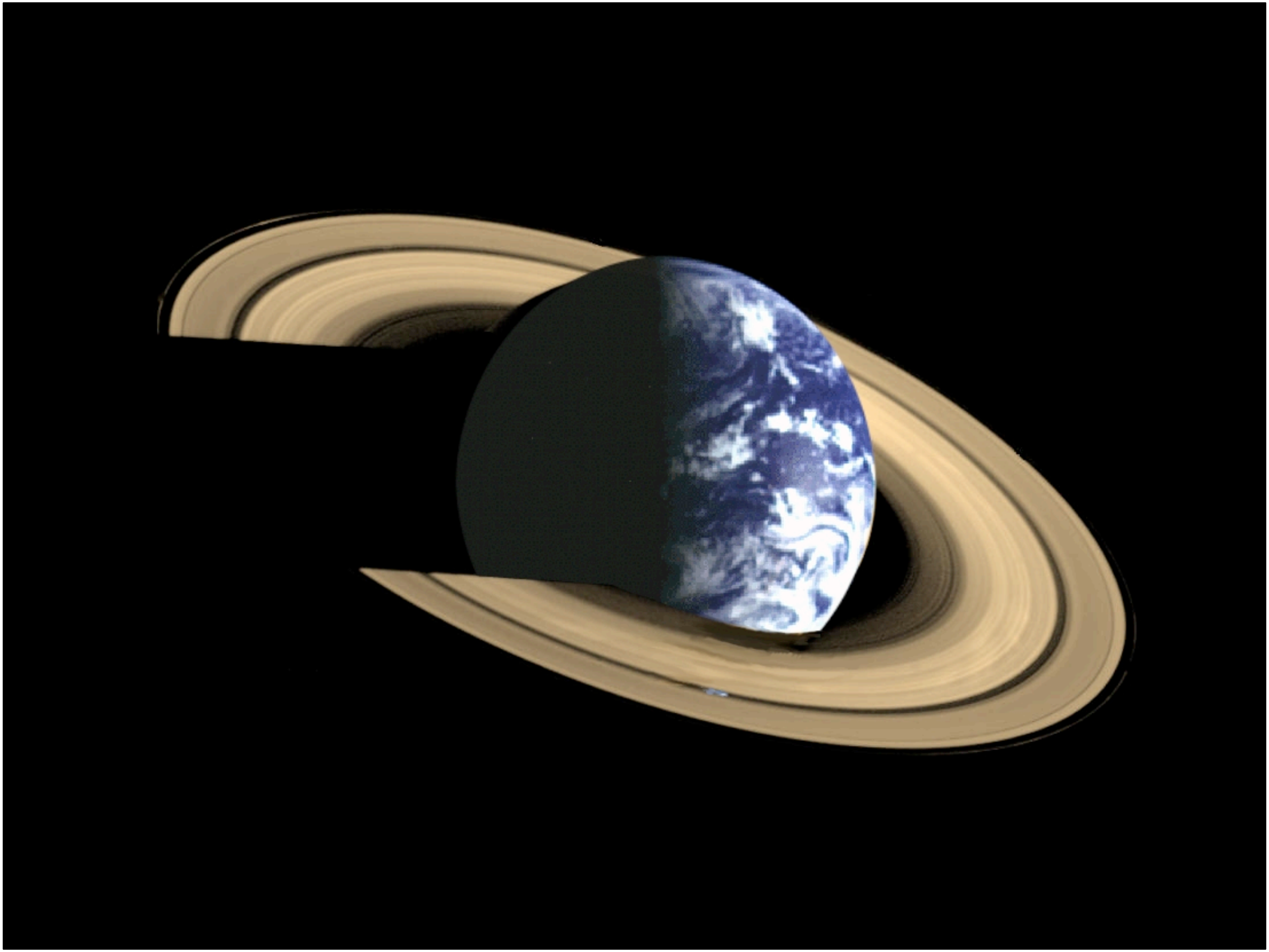




Kepler's third law: The further away a satellite is from a planet, the lower its speed.

If a satellite is weak, the inside and outside edges are pulled in different speeds, pulling the satellite apart. Effect is largest near the planet.

Particles inward of ‘Roche radius’ spread to form ring, or
Particle outward of Roche radius stick to form satellites



Open Problems in Ring Dynamics

Are rings really young?

How variable are the rings?

What do individual ring particles look like?

How do ring systems interact with the space environment?

Why are ring systems so different?

If it's so simple, why haven't we solved everything yet?

We don't know the values of key parameters of the solar system!

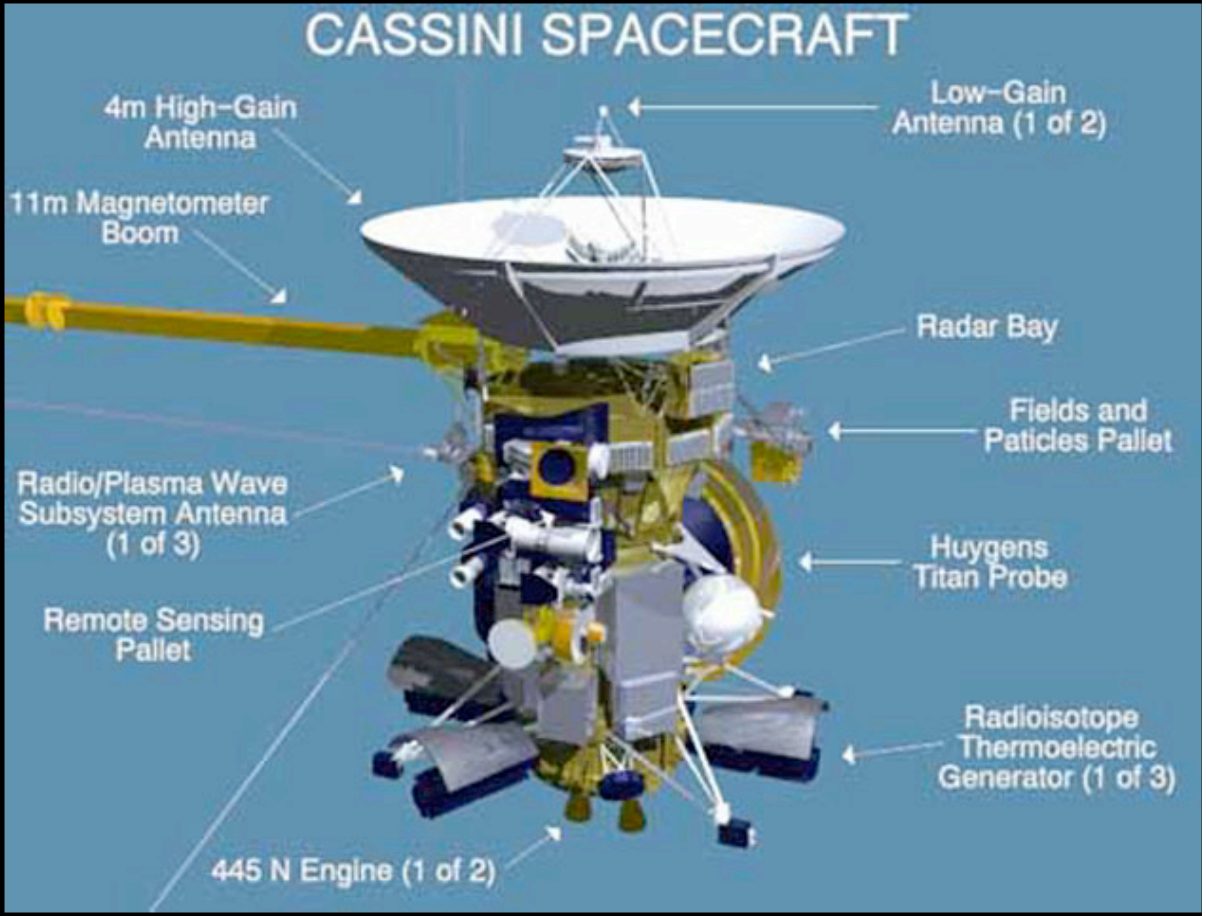
Numerical simulations can reproduce but not explain results!

The Cassini Mission to Saturn

Spacecraft will orbit Saturn and study atmosphere, rings, and satellites for 4 years

Spacecraft has 13 instruments

- Infrared, visible, ultraviolet cameras
- Spectrometers
- Radar
- Dust detector
- Magnetometers
- Plasma detectors
- Probe (six instruments)



'Lamborghini of spacecraft'

Cassini Mission to Saturn - Statistics

$2.5 B
~150 associated scientists, 500 engineers

6000 kg Cassini orbiter (NASA)
    300 kg science instruments
    3000 kg propellant
1000 kg Huygens atmospheric probe (European Space Agency)
    30 kg science instrument

Funding start:	1989
Launch:	October, 1997 on Titan IV, 1 M kg
Arrival:	July 1, 2004
End of mission:	July 1, 2008

Data returned: ~ 1 gigabyte/day for 4 years
    Cassini will return more data than all previous interplanetary spacecraft combined!

Why send a spacecraft?

In situ measurements possible

Probe, dust detectors, etc

Fine spatial resolution

Spatial resolution ~ (Distance to object)(wavelength)/(mirror size)

Hubble Space Telescope: 100" mirror to see 10^9 km/pixel resolution

Cassini: tiny, 8" mirror (!) to see 1 km/pixel resolution

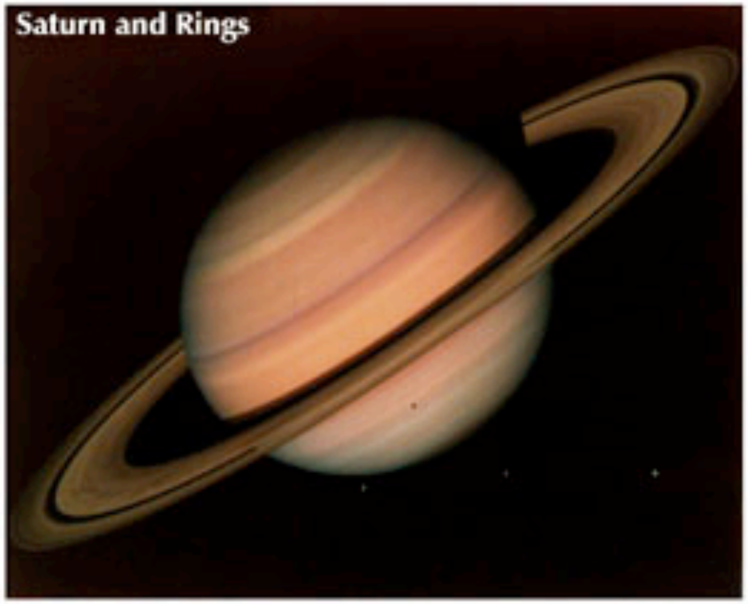
Disadvantages of spacecraft

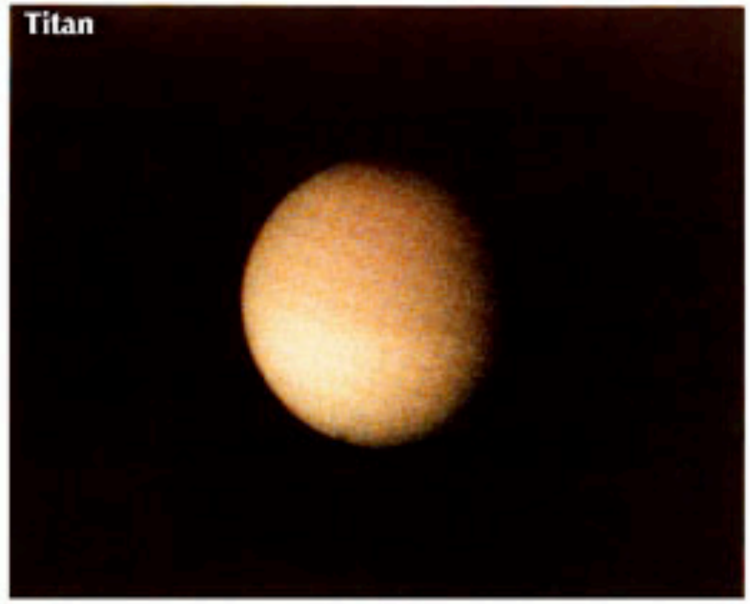
Costly

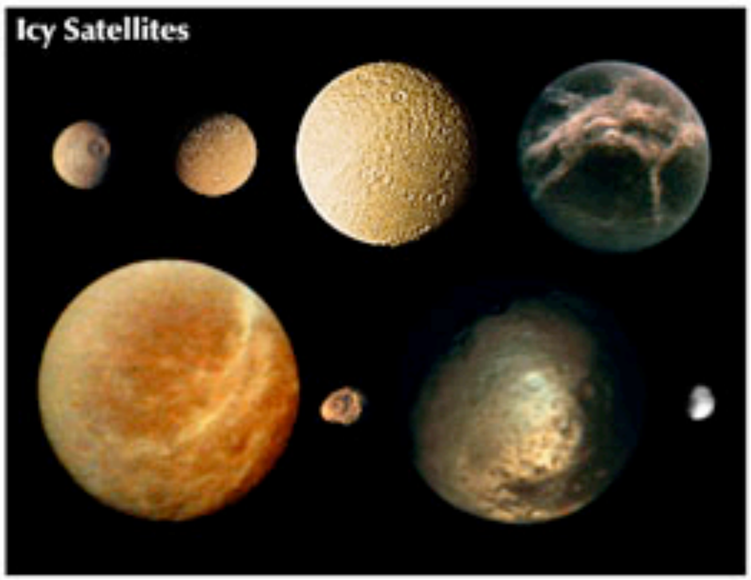
Inflexible

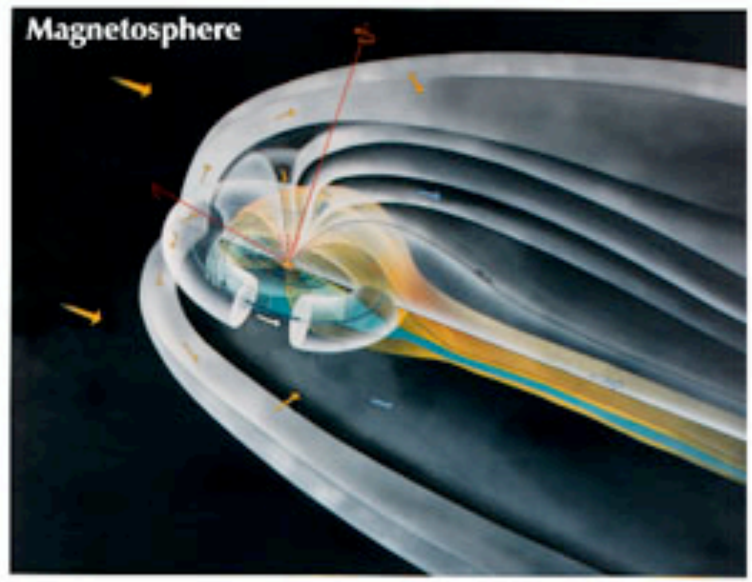
Can't fix it!

Cassini Science Targets

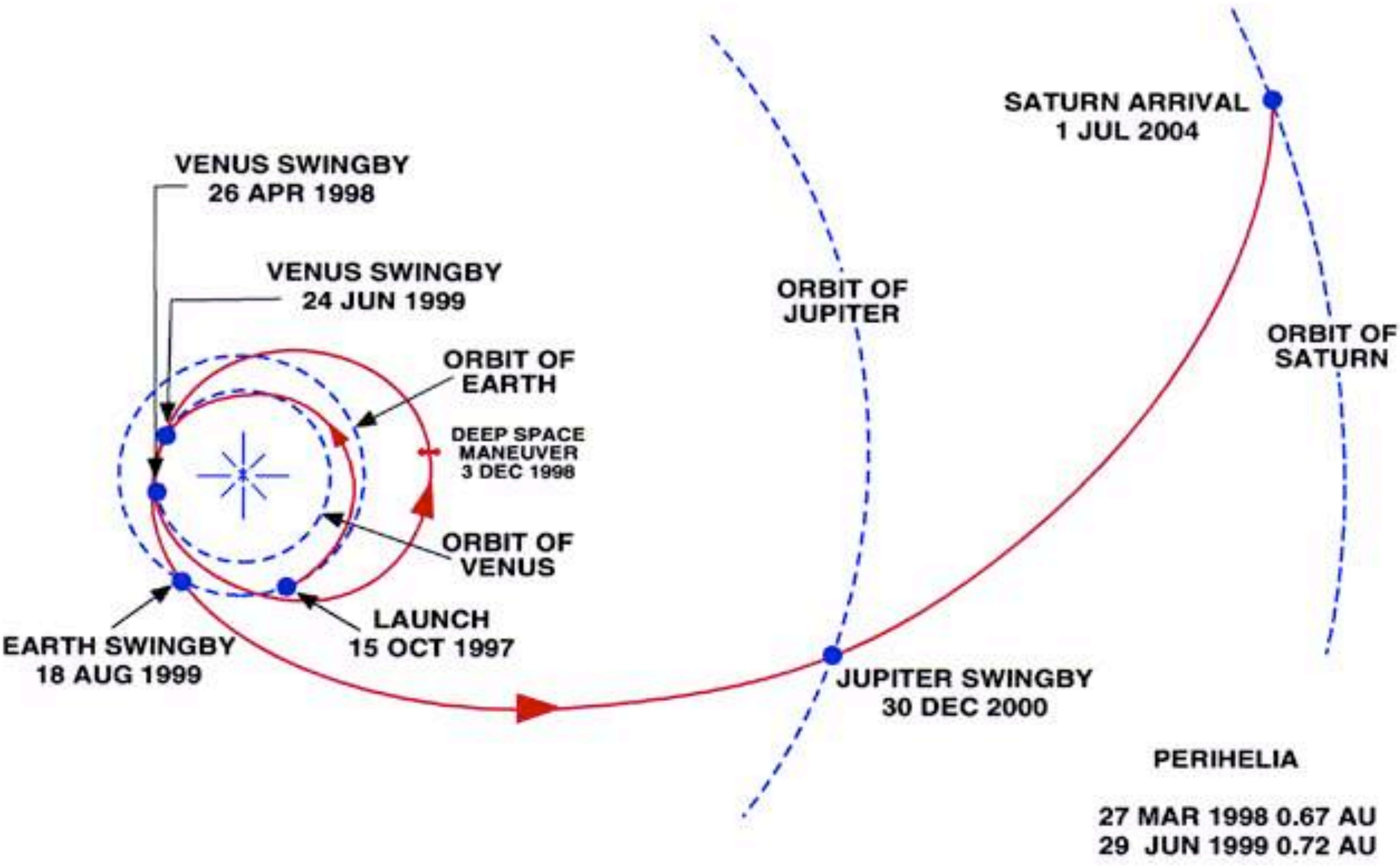








CASSINI INTERPLANETARY TRAJECTORY



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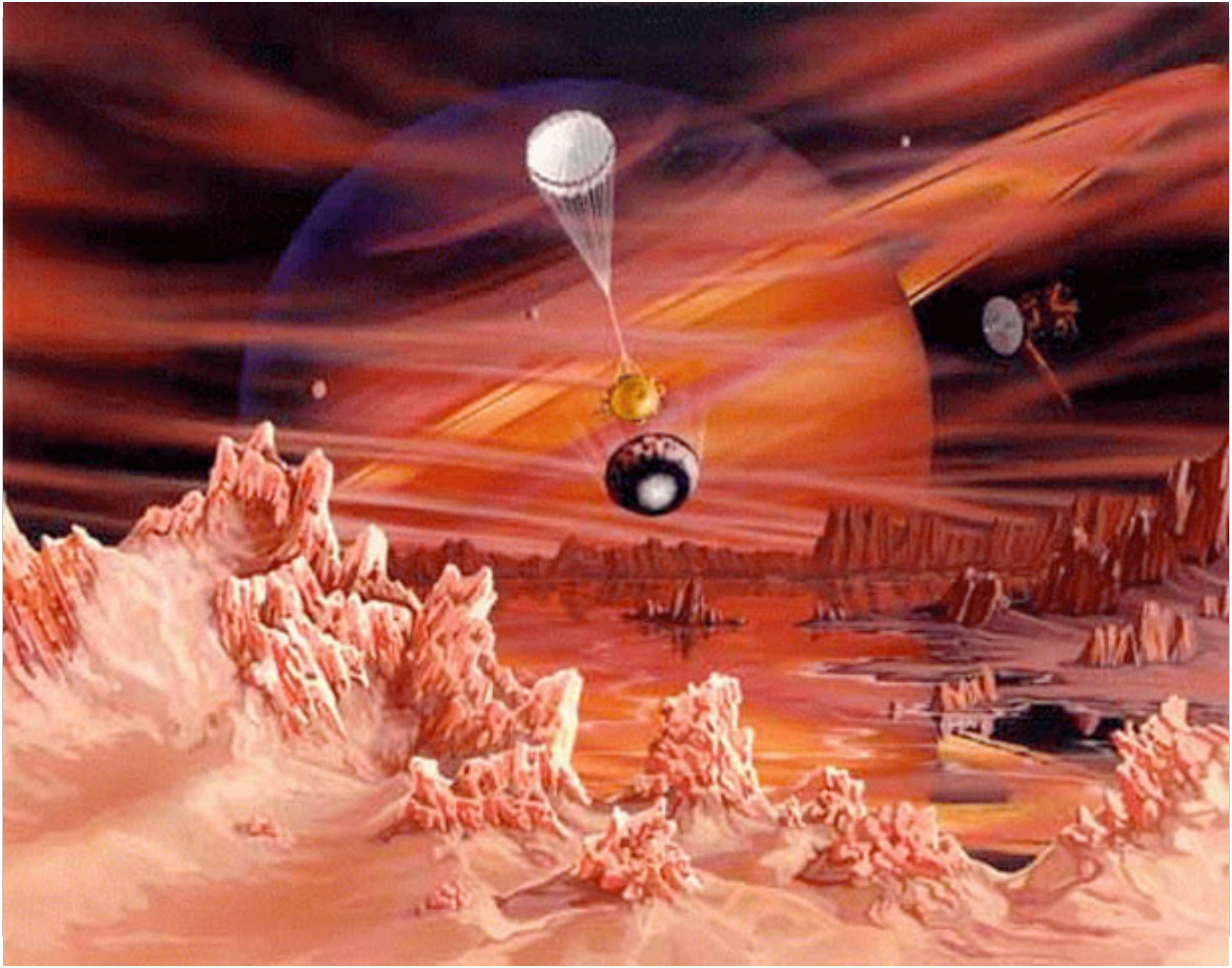
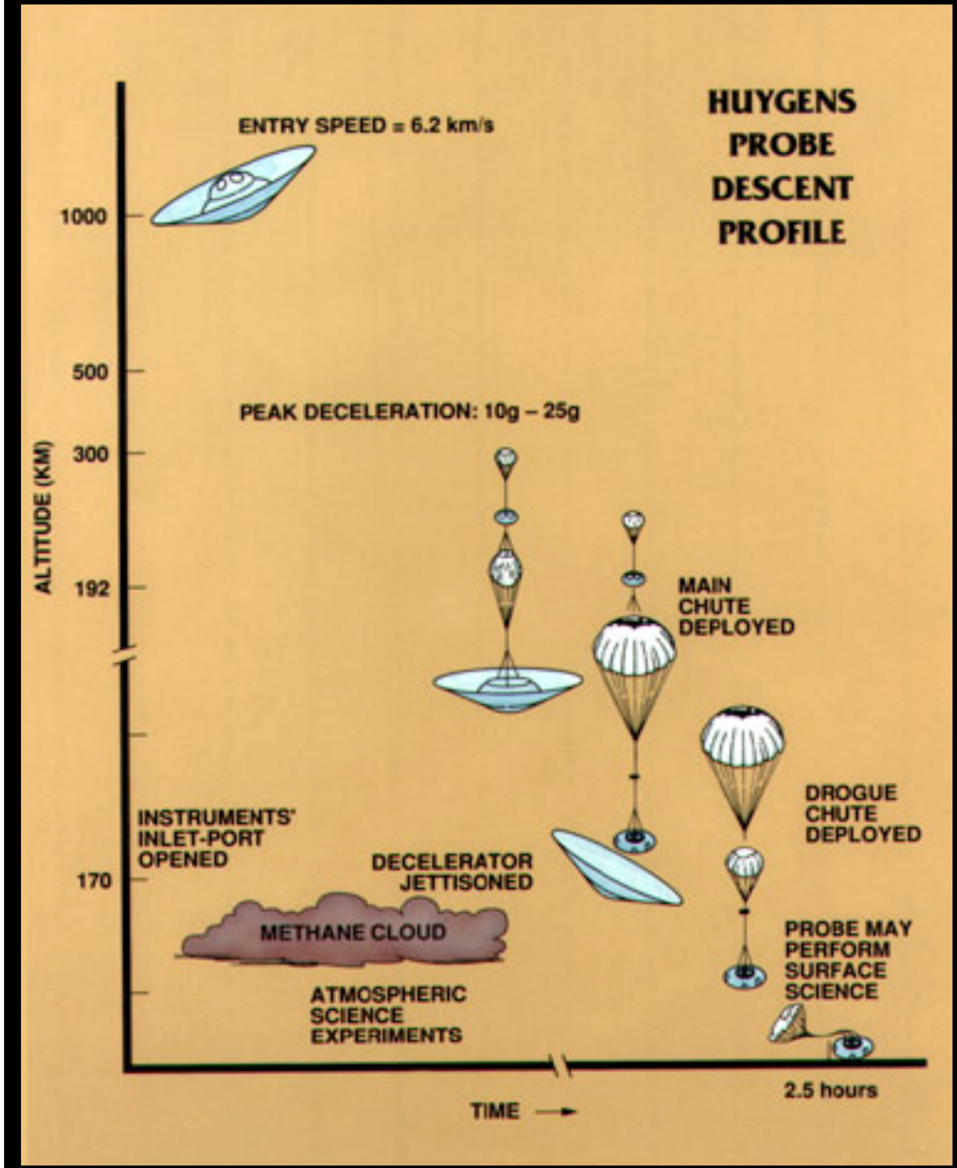


Titan



Does Titan have oceans?

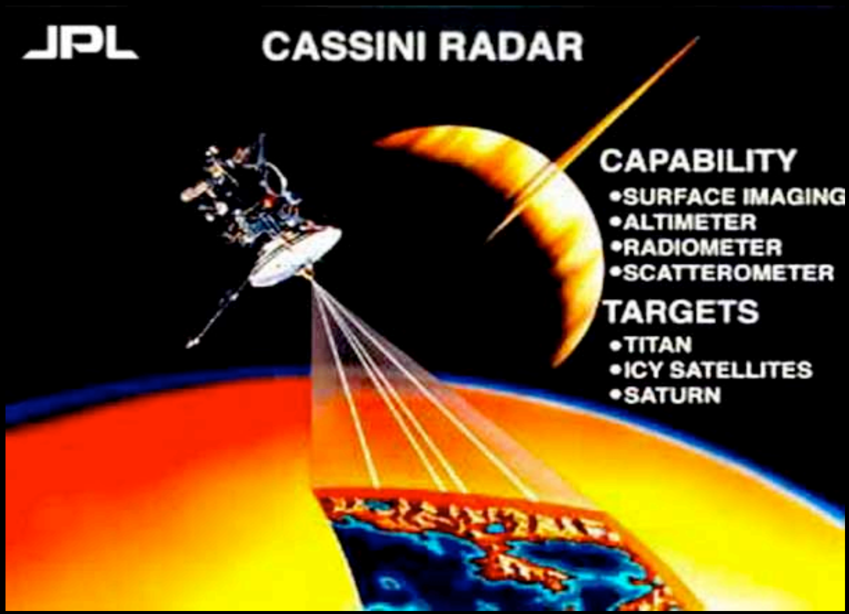
Earth only place in SS with liquid

Europa pehaps sub-surface liquid

Atmosphere of methane, nitrogen

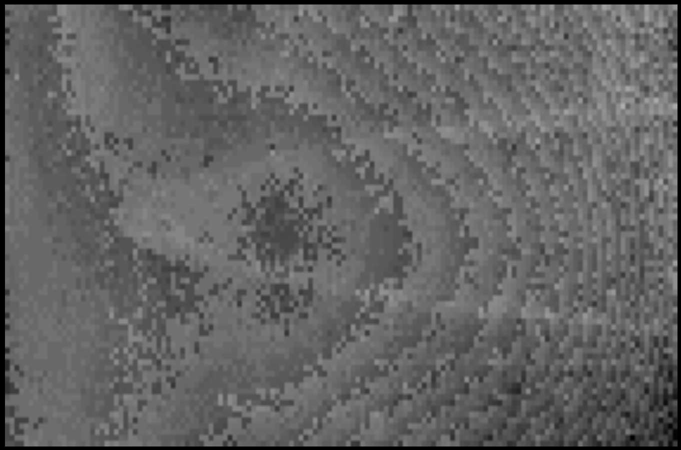
Much atmospheric chemistry

Could Titan support life?



Cassini Jupiter Flyby
December 30, 2000

Cassini flew past Jupiter, used it for a gravity-assist flyby



New Jupiter atmospheric movies!

New ring movies!

New images of small satellites!

Io volcanoes glowing in eclipse!

Cruise science (coming up in April!)

Imaging of dust from asteroid belt ('Zodiacal dust')

Search for rings around Mars