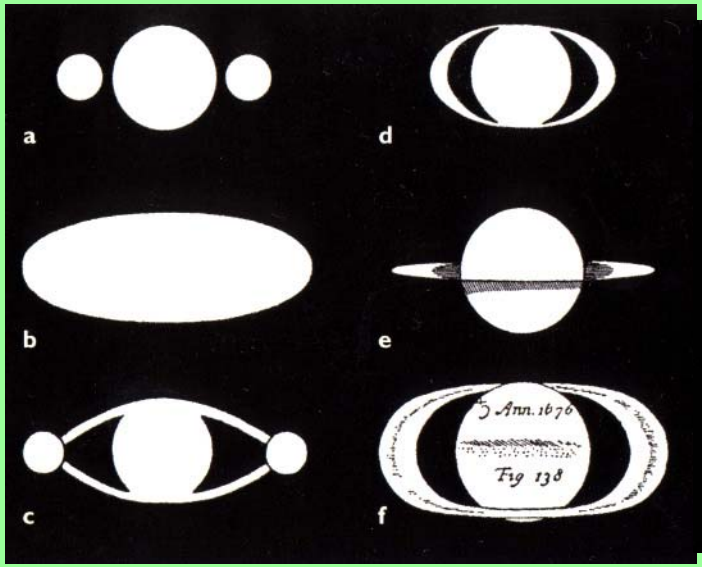
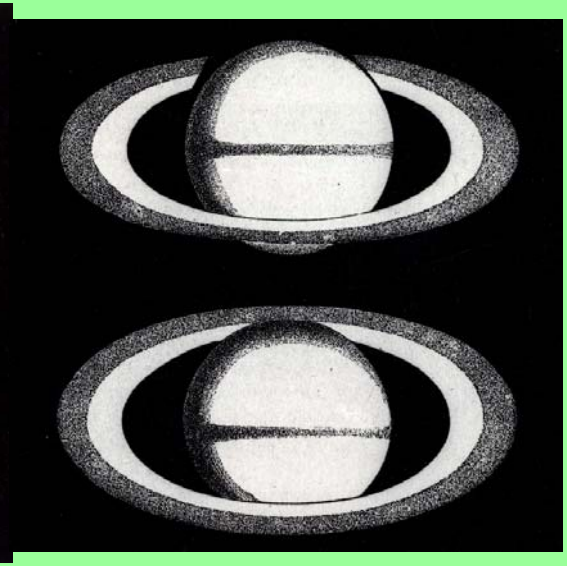
STABILITY, RESONANCE, & K.A.M. in SATURN'S RINGS

SATURN: VIEW from EARTH



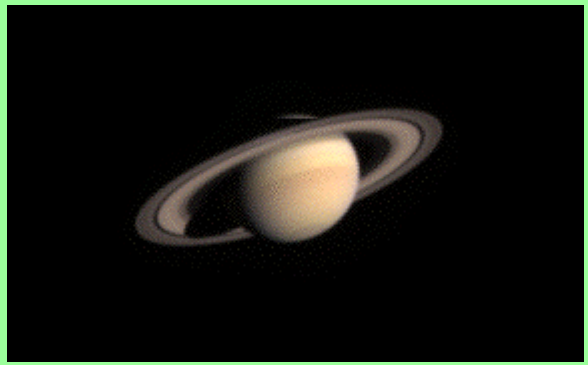
Saturn observations: (a) Galileo-1610 (b) Gassendi- 1634 (c) Fontana- 1646 (d) Riccioli- 1648 (e) Huyghens- 1655 (f) Cassini- 1676



Drawings of Saturn- Cassini (1675) Showing the distinction between A & B rings

The invention of the telescope in 1608 revolutionised science. Amongst many other things this allowed a 1st look at the planets, & showed a fascinating picture of Saturn. It was the remarkable Dutch scientist C. Huyghens who gave the correct interpretation of what was seen through these very primitive instruments- that Saturn was surrounded by a ring. Later observations with better telescopes showed gaps in the rings, principally the famous 'Cassini division' (left).

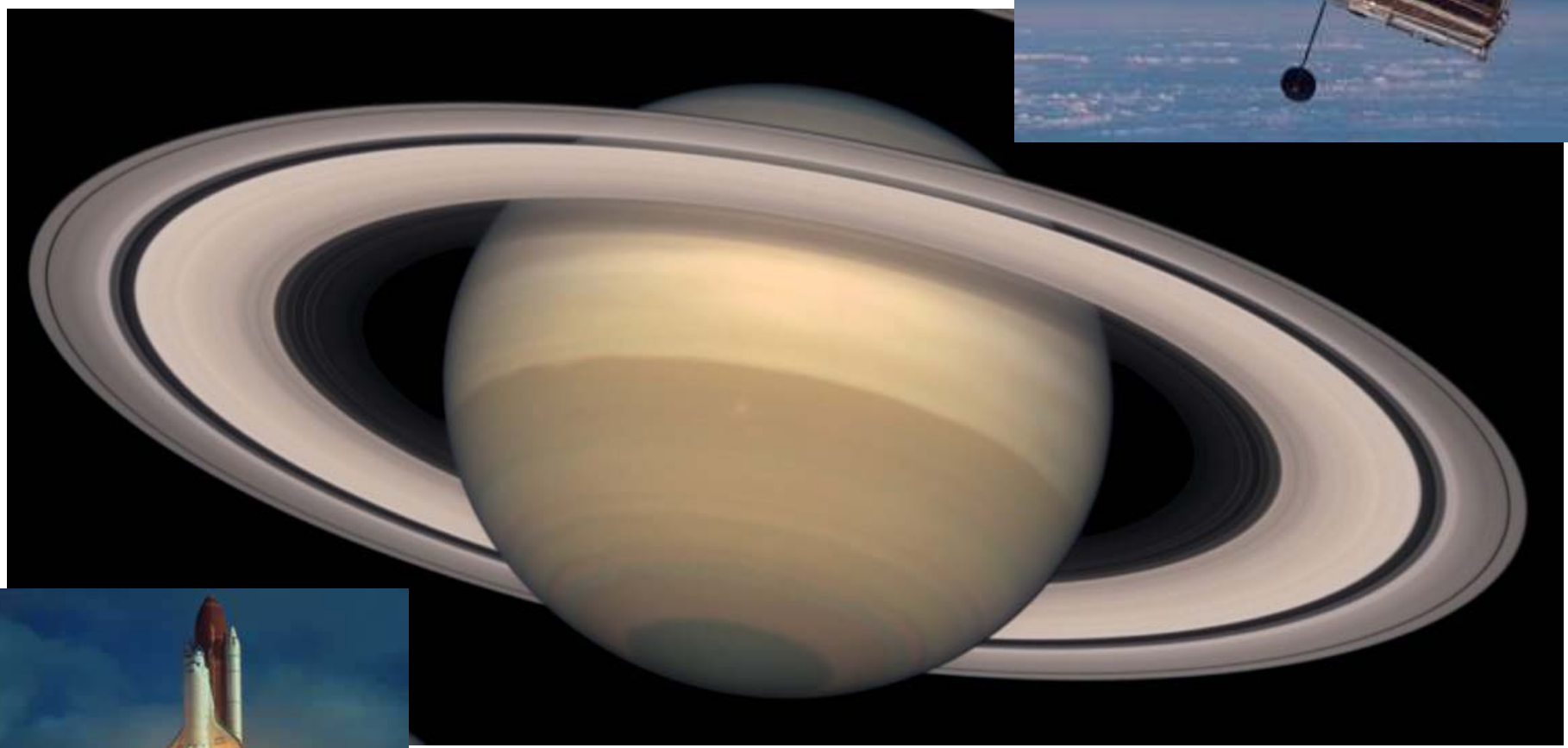
Our telescope-based knowledge of Saturn's orbital motion is now so precise that we can accurately predict its motion for the next 100 Myrs (including perturbations from the other planets, etc). Any small modern telescope will show the rings clearly. The puzzle of the rings was unraveled theoretically by Maxwell in 1857, who showed that they must be composed of a very large number of small particles- this was verified by Doppler shift observations at the end of the 19th century. Nevertheless observations from powerful 20th century earth-based telescopes showed the rings to be very stable, and moreover very thin- far too thin to be resolved from earth when viewed edge-on. Saturn's rings are colossal, with diameter nearly 273,000 km, but with very little mass- what can keep them stable from the perturbations caused by Saturn's many satellites, passing bodies, the solar wind, etc?



View at the eyepiece of a large (~3-4 m diameter mirror) Earth-based telescope

The VIEW from HUBBLE

In the 1990's the launch of the remarkable Hubble telescope into Earth orbit gave us remarkable full-time access to Saturn at an unprecedented resolution (although the mirror is only 2.5 m across, atmospheric distortion is no longer a problem)

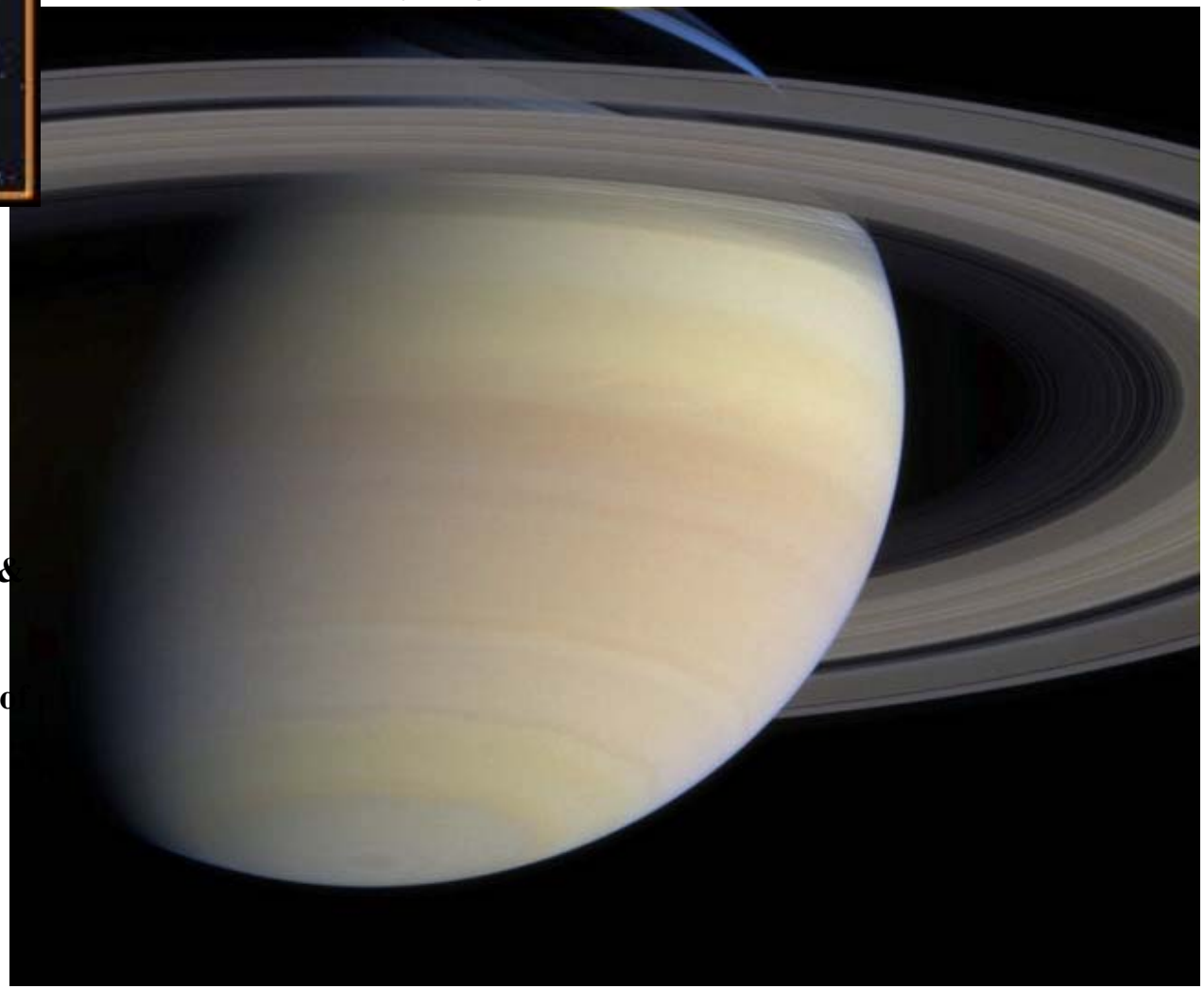


In this Hubble photo we clearly see the 4700 km wide Cassini division, at the outer edge of the bright B ring, & the 600 km wide Encke gap near the edge of the outermost A ring. One can faintly discern much smaller scale structure in all 3 rings (particularly in the faint C ring, just inside the B ring- and even inside the Cassini division).

SPACE PROBES to SATURN

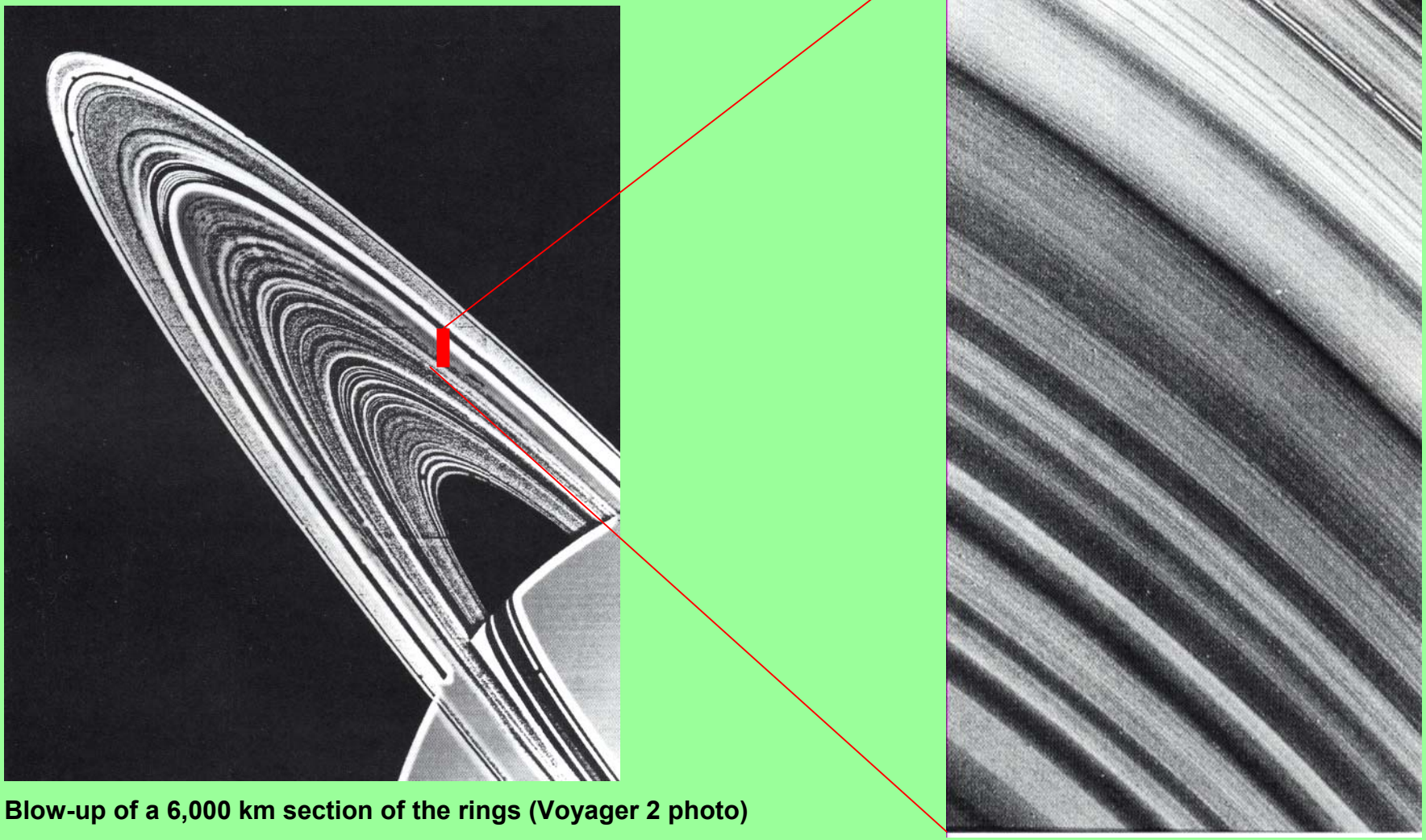
Our knowledge of Saturn, particularly of it
changed completely when the Voyager robot
Arrived there in Nov 1980 and Aug 1981. Even from a great distance, Voyage
photos showed a ring structure that beggared the imagination- and close-up
photos defied belief (see next slide, and also the slide presentation after this).
should have been expected, after star occultation photos had revealed in 1977
existence of filamentary rings around Uranus- but it was not.

Artist's rendition of the approach of Voyager 1 to Saturn in 1980



The Voyager missions completely changed our knowledge of the Solar System. They were launched in Aug & Sept 1977; and both visited Jupiter & Saturn- Voyager 2 went on to Uranus & Netptune, in a 'grand tour'. Both are now very far from the sun, at nearly 10 billion km (twice the orbital radius o Pluto); but they are still transmitting. These missions must go down as one of the most successful team projects in scientific history.

STRUCTURE of the RINGS

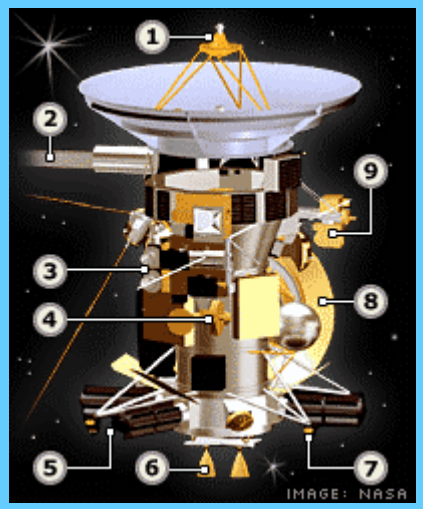


Blow-up of a 6,000 km section of the rings (Voyager 2 photo)

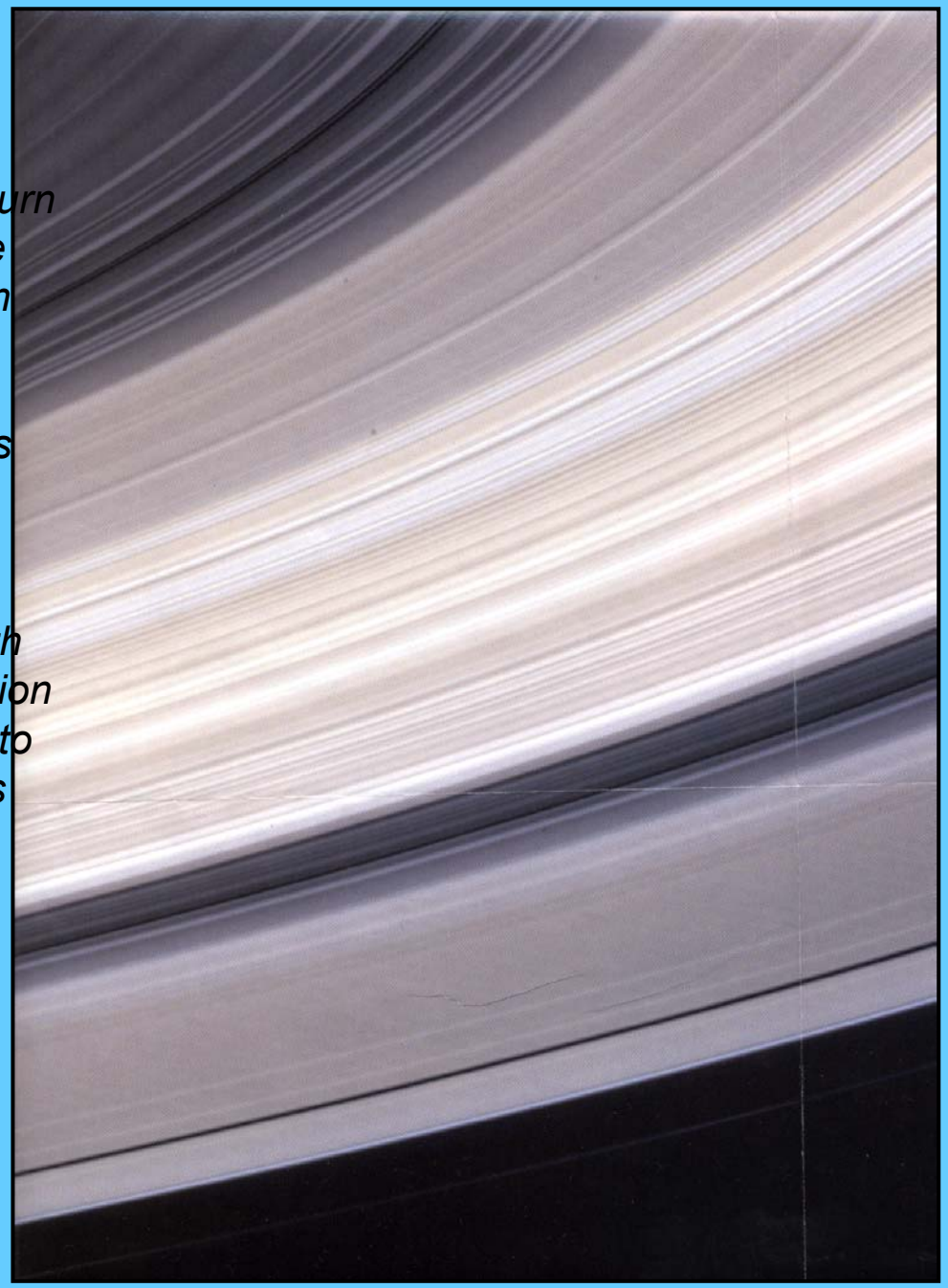
Close-up photos of the rings from Voyager show a quite incredible structure, betraying a delicate yet stable nested structure quite undreamt of from Earth, and extending down to scales of only a few km. Occultation observations by Voyager revealed structures in the rings down to only 10 m in size (about the size of the largest ring particles), with incredibly complex ringlets even in the divisions.

SATURN from the CASSINI PROBE

On July 2004 the **Cassini** *probe arrived at Saturn & began its 4-yr exploration of the system. The highlights of this mission will include the launch of the* **Huyghens** *probe, which will descend to the surface of the remarkable moon Titan in Jan 2005- & a very close inspection of Saturn's rings and its other moons. We expect some fundamental questions about both Saturn & the formation of the solar system to be answered by this mission.*



1. Antennas enabling communication
2. Boom carrying magnetic field probe
3. Two cameras will take 300,000 pictures of the planet
4. IR spectrometer analyses temperature & composition
5. Radioisotope thermoelectric generators supply 750W
6. Cassini has 2 engines - one is a back-up
7. Thrusters for small changes of direction or speed
8. Huygens probe will land on Titan
9. Plasma spectrometer detects charged particles



Rings seen from Cassini probe- July 2004