Astro 1: Introductory Astronomy

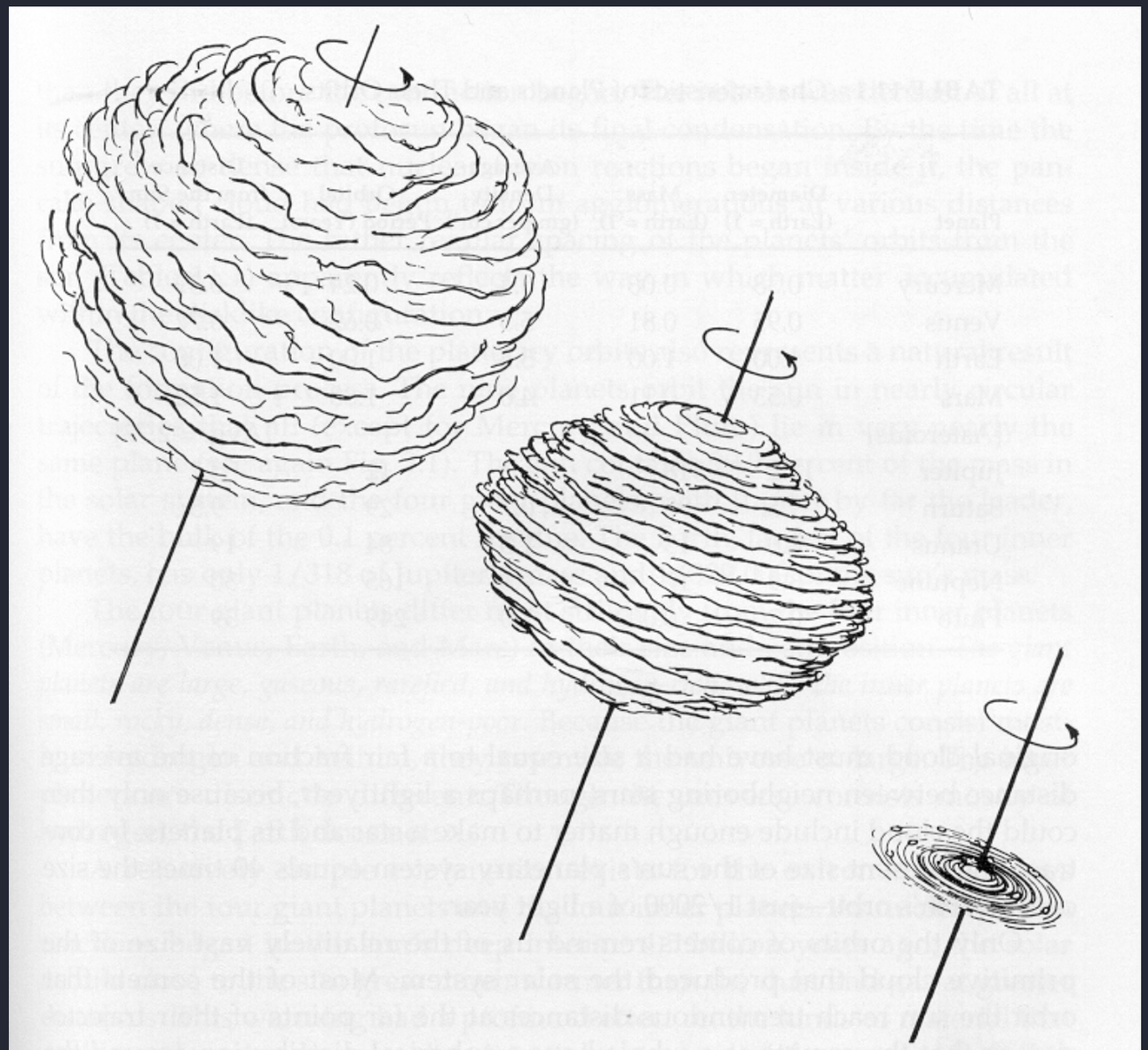
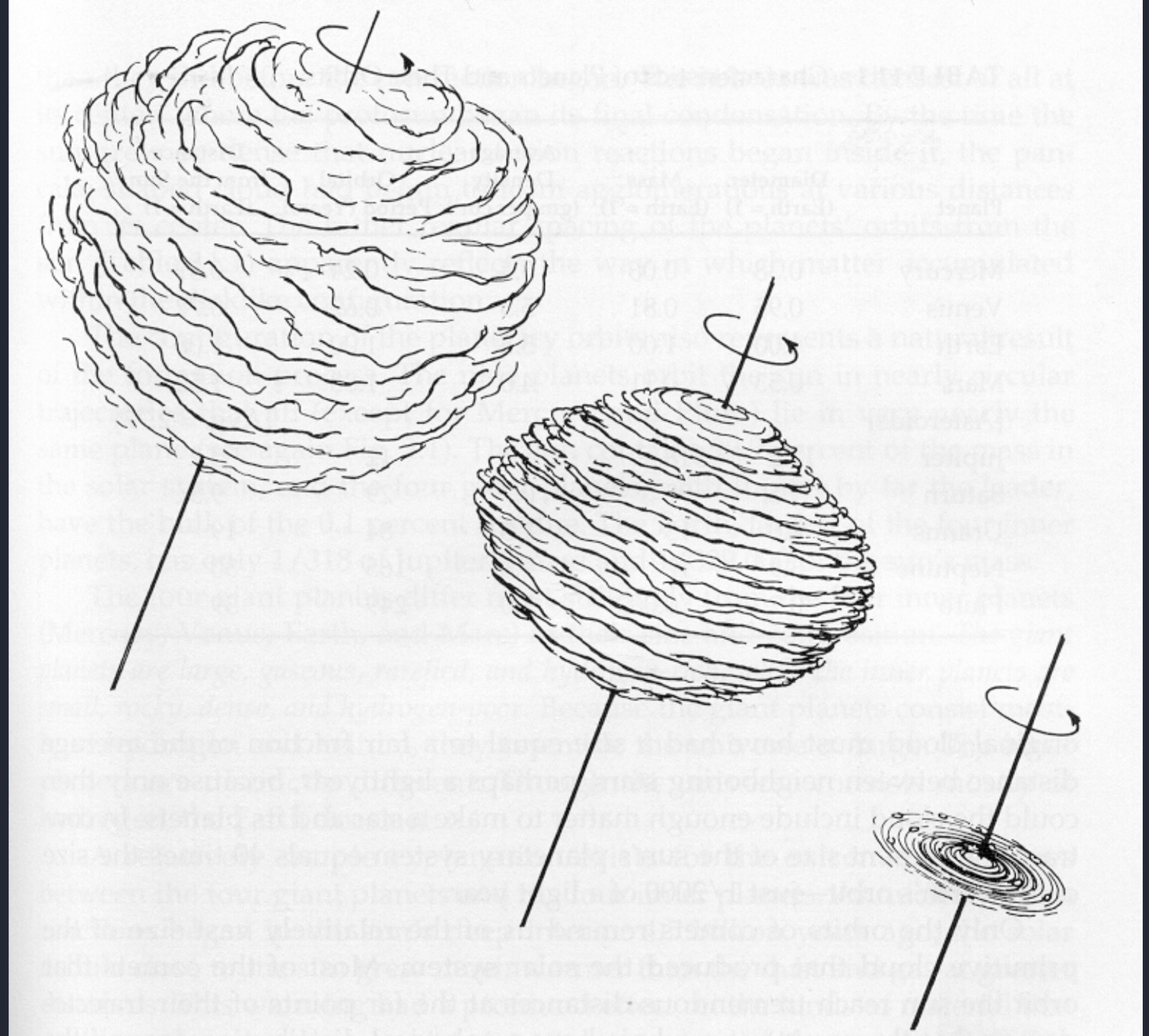


Figure 11.2 As the cloud of gas and dust that formed the solar system began to contract, it must have acquired some rotation, which led to more rapid rotation as the cloud grew smaller. This rotation tended to support the cloud against contraction in directions perpendicular to the axis of rotation, and thus led to a pancake-like shape for the contracted, rotating cloud. Within the disklike configuration, the individual planets accreted from the matter revolving at their present distances from the sun.



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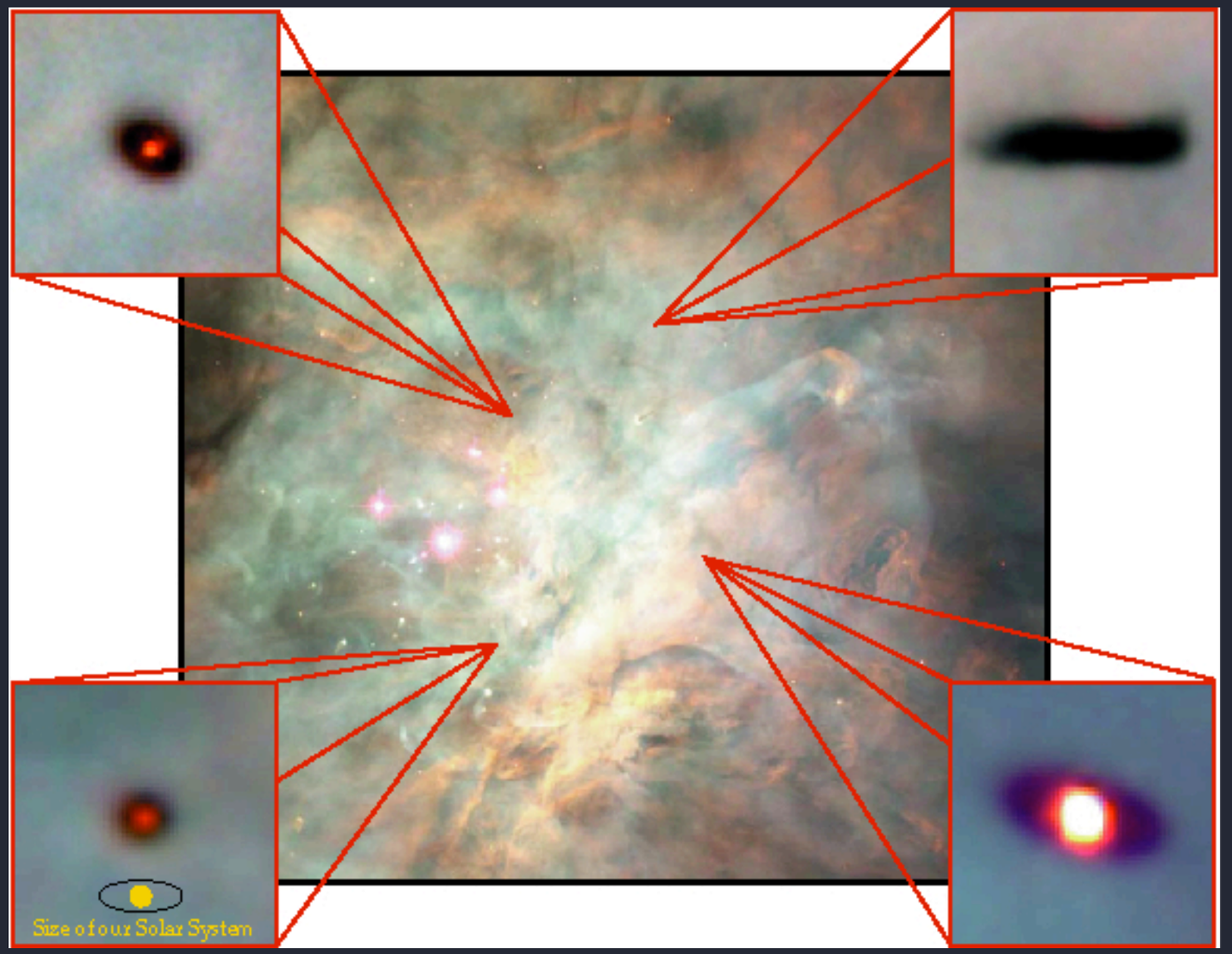
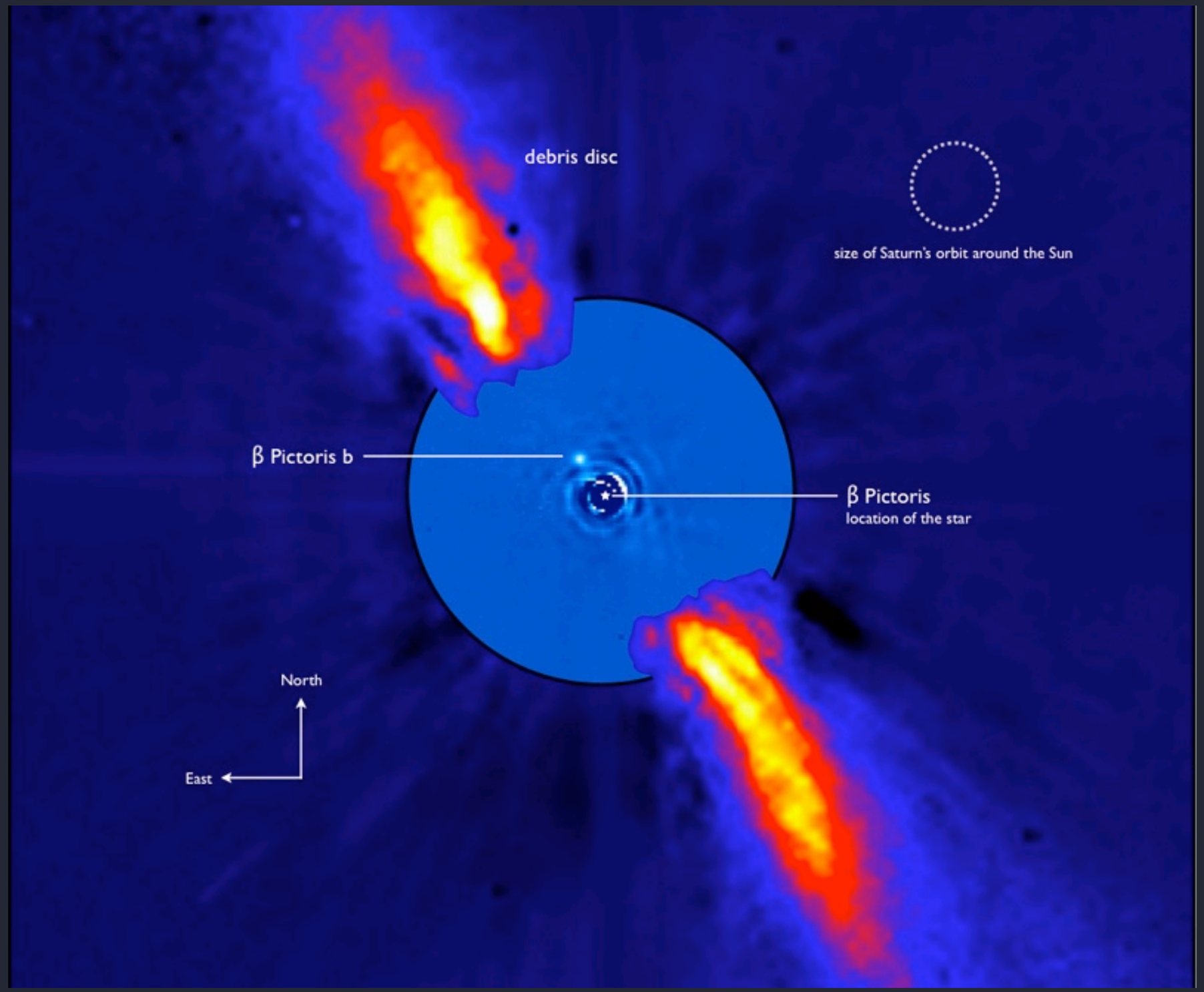

Size of our Solar System


debris disc
size of Saturn's orbit around the Sun
β Pictoris b
β Pictoris
location of the star
North
East

large cloud of interstellar gas and dust - giving birth to millions of stars

Hubble Space Telescope: Carina Nebula

super-high resolution: *http://hubblesite.org/gallery/album/heritage/pr2007016a/*

Explaining why the Jovian planets are farther from the Sun, have a different composition, and are bigger than the Terrestrial planets.

In the protoplanetary disk, places farther from the Sun were cooler, and beyond the snow line ($T \sim 150$ K, $d \sim 2$ A.U.) hydrogen compounds were in solid form; they were ices. Planets build up by accretion of planetessimals that themselves build up from smaller solid particles. Since there were more particles, including ices, in the outer Solar System, planets farther from the Sun are bigger and have more hydrogen in them.

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Plus, those bigger outer protoplanets had enough gravity to pull in lots of gas that was in the disk initially. So that makes them a lot bigger, even.

Jupiter cross section: a lot of hydrogen - gas pulled in by proto-Jupiter's gravity

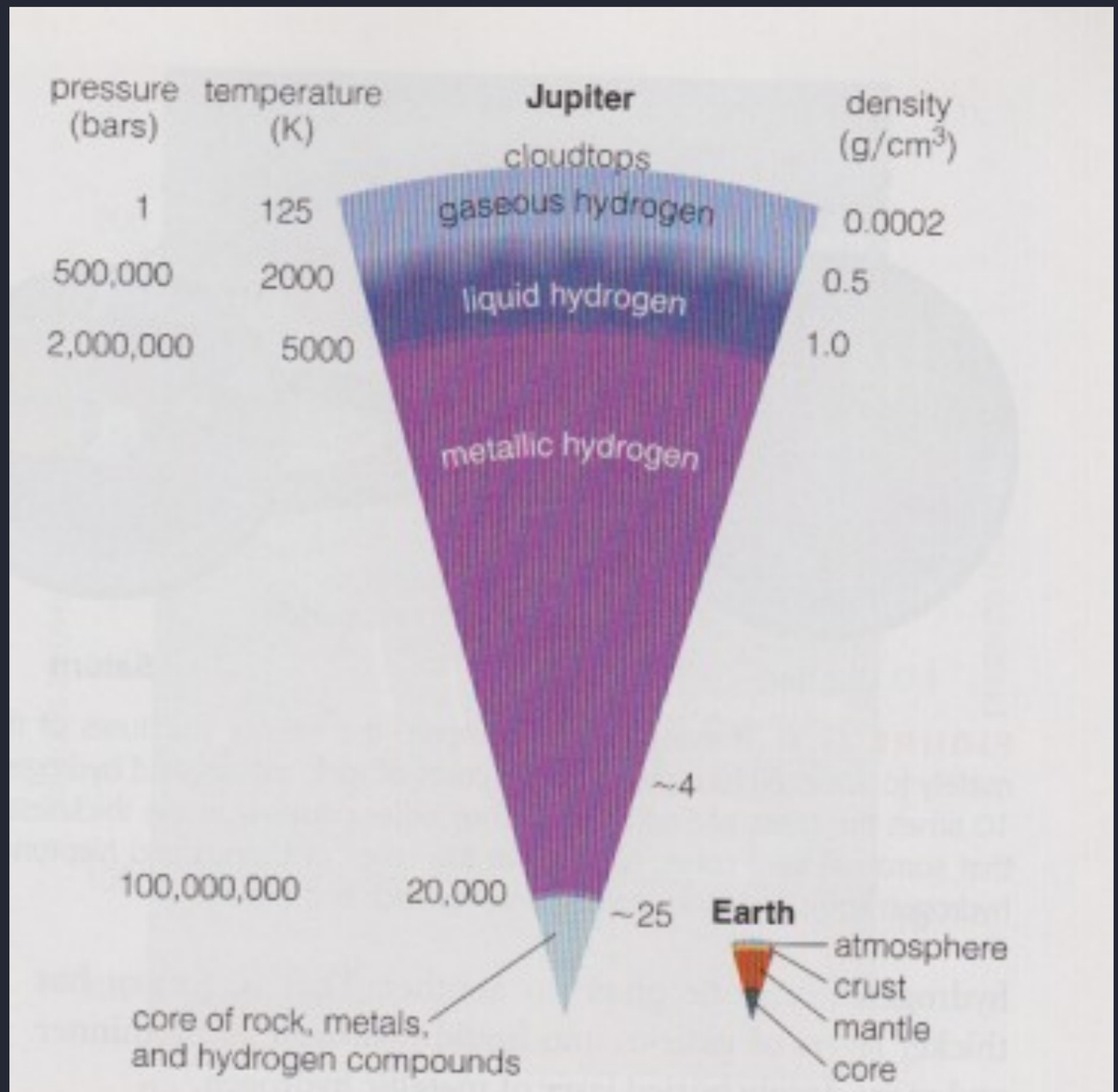
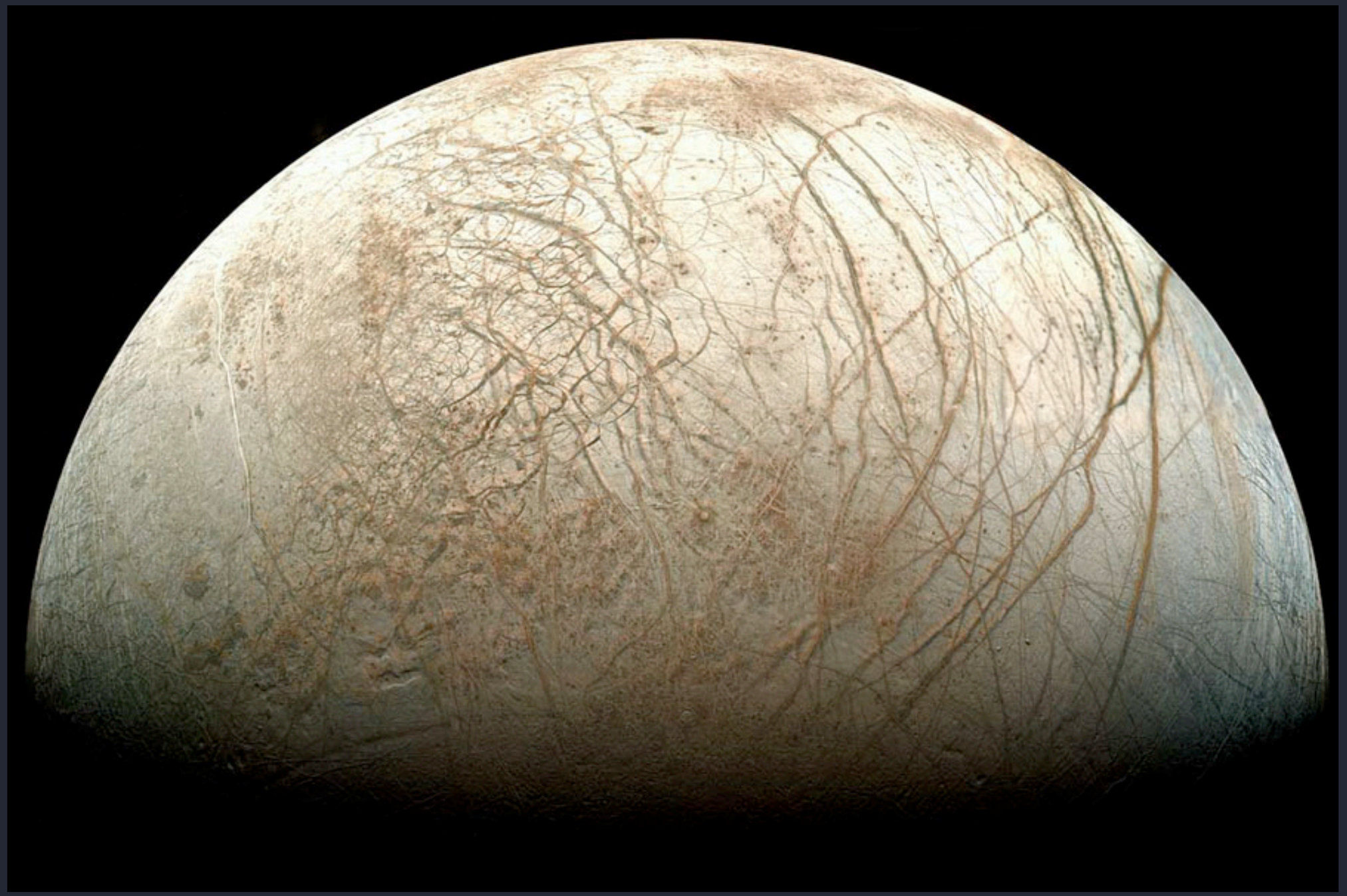


FIGURE 11.4 Jupiter's interior structure, labeled with the pressure, temperature, and density at various depths. Earth's interior structure is shown to scale for comparison. Note that Jupiter's core is only slightly larger than Earth but is about 10 times as massive.

Europa – covered with salt-water ocean

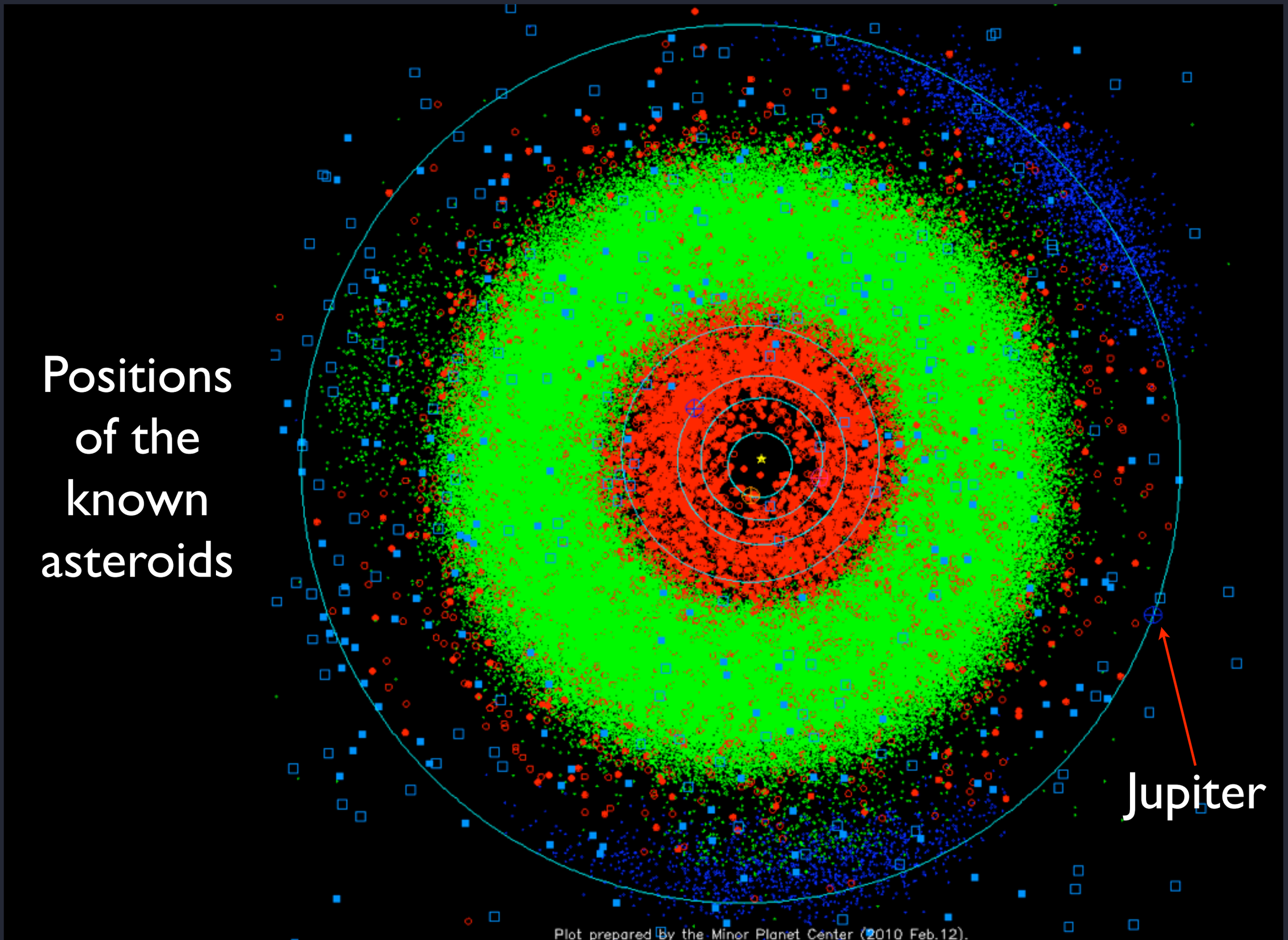


What does the nebular model explain?

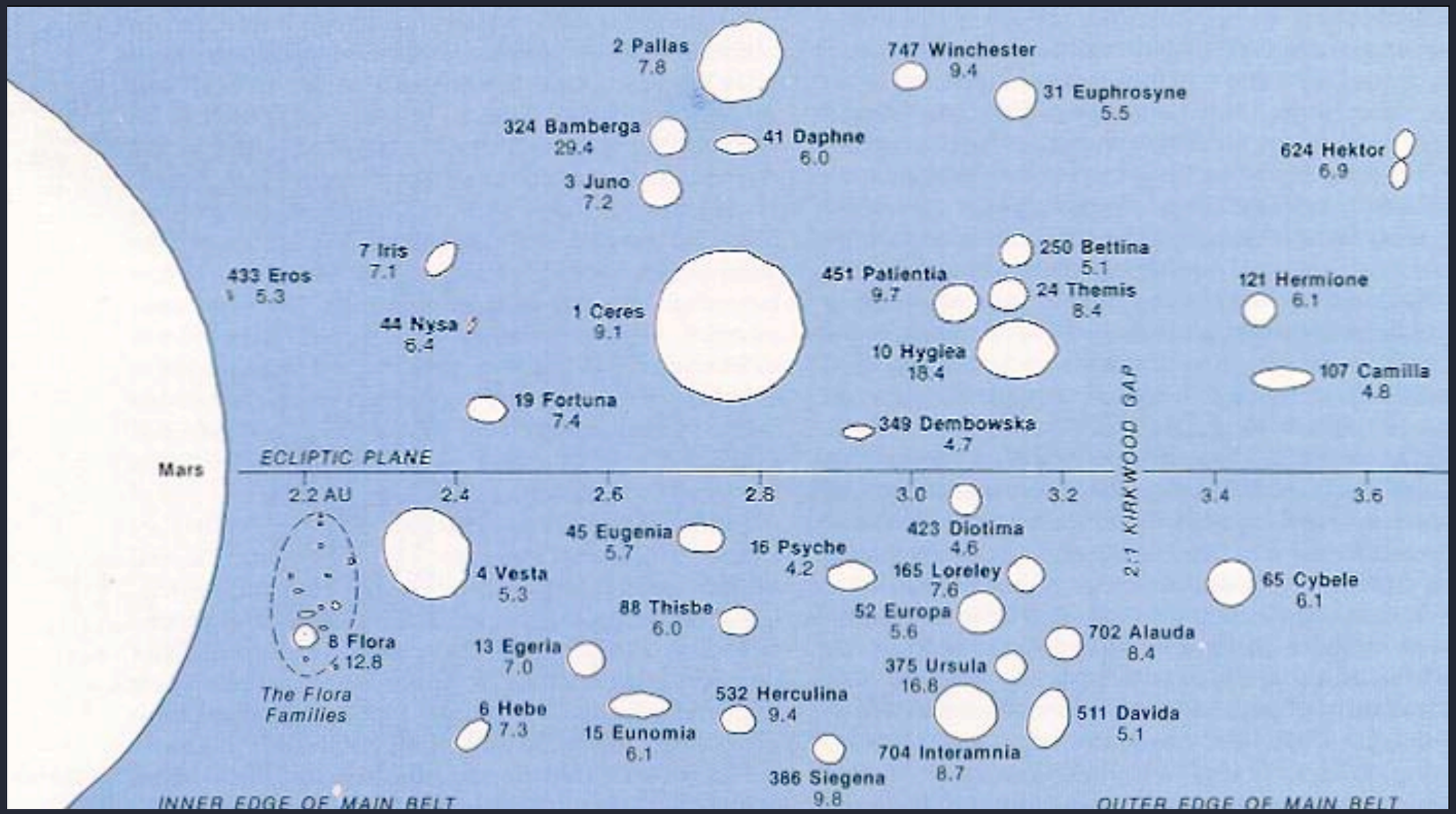
3. Asteroids and Comets

left over planetessimals – never combined into proto-planets (and then planets) because they were in low-density regions of the nebula (Kuiper belt) or somewhere where nearby planets' gravity interfered with them (asteroid belt) condensation temperature of metals and rock is high enough (>1000 K) so that these substances were solid, even very near the Sun; But ices (recall: not just water, but ammonia and methane) were gaseous near the Sun and only condensed into solids far from the Sun ("ice line" between Mars and Jupiter)

Positions of the known asteroids



Relative asteroid sizes

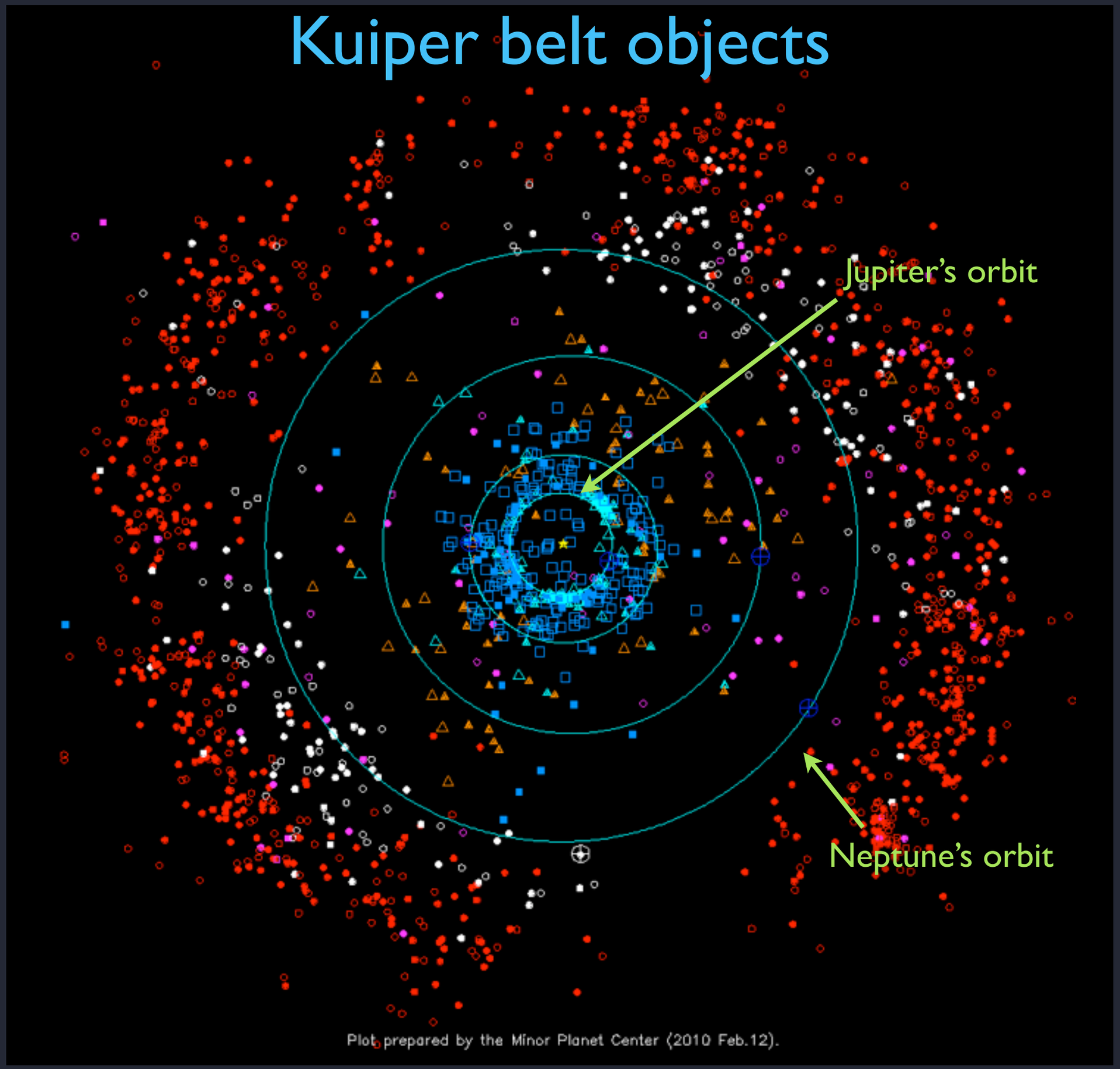


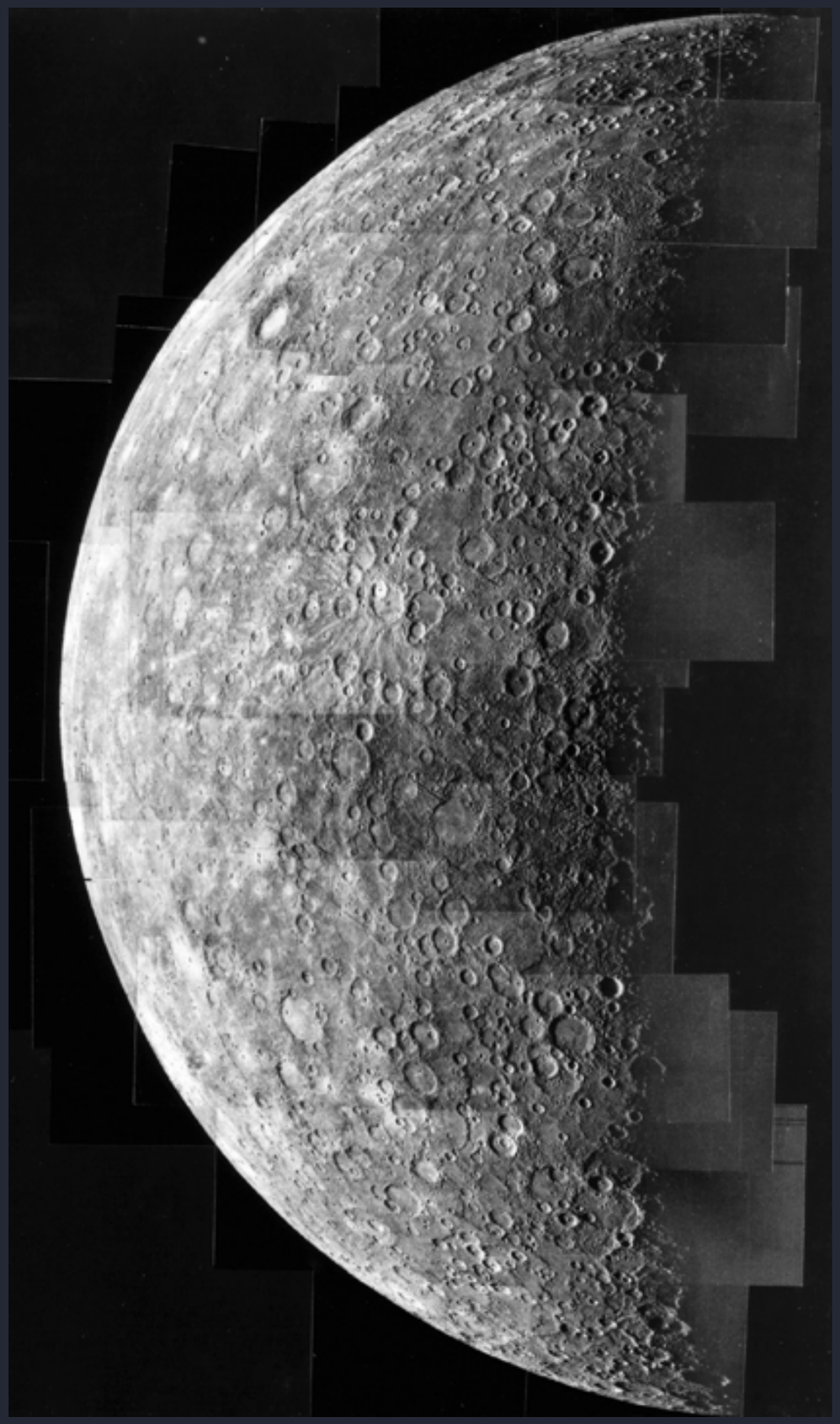
Comet McNaught

Comet Temple

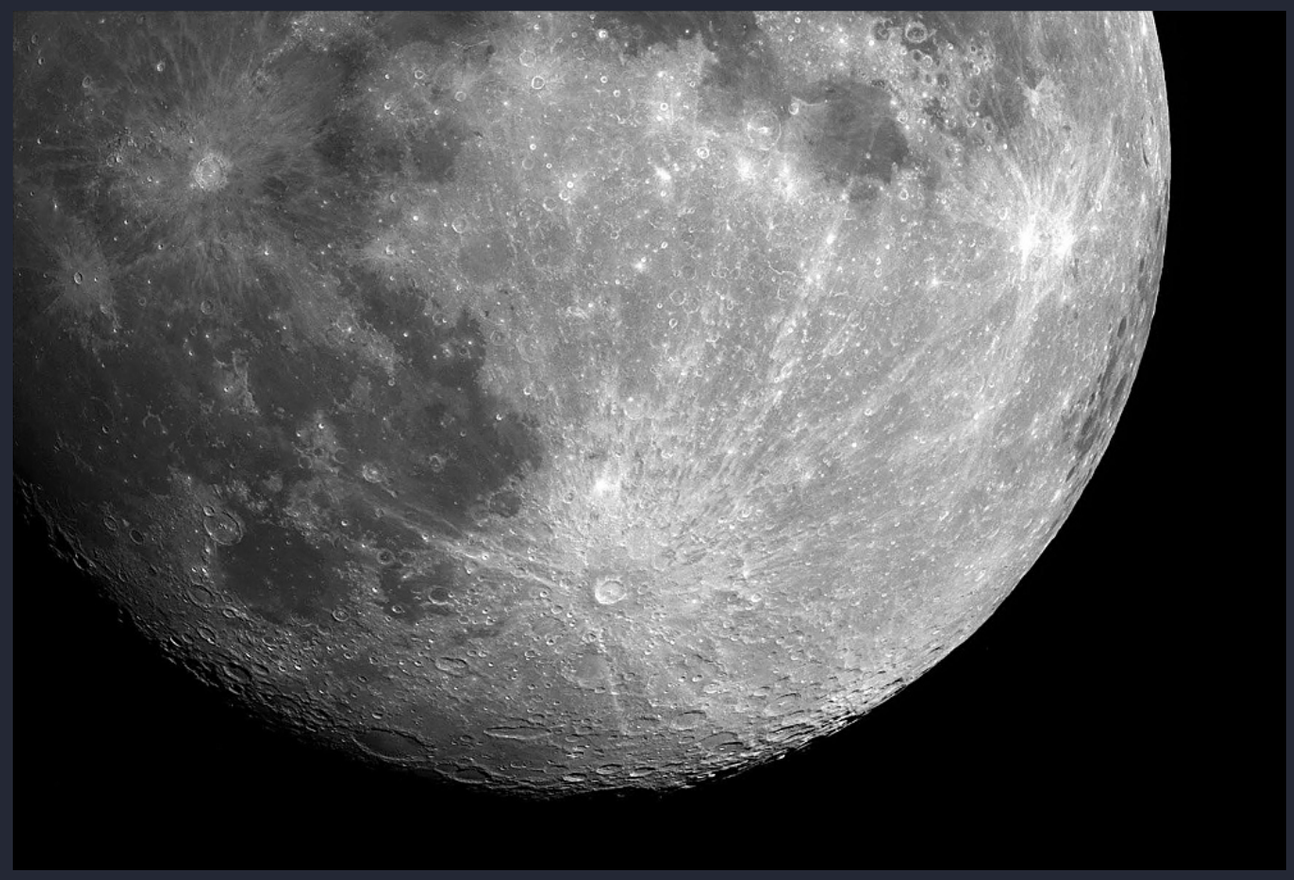
Comet Temple's nucleus

Kuiper belt objects

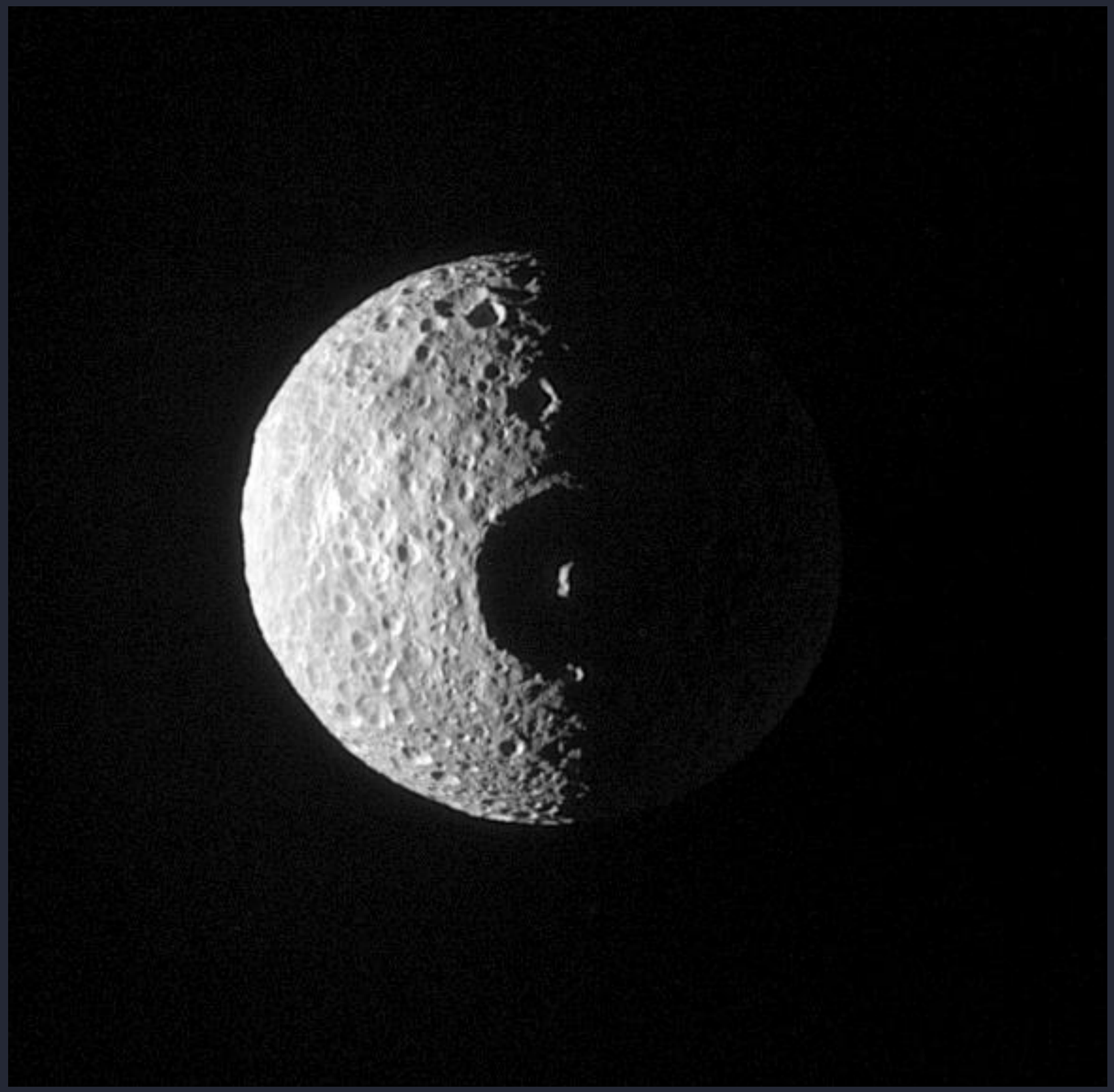




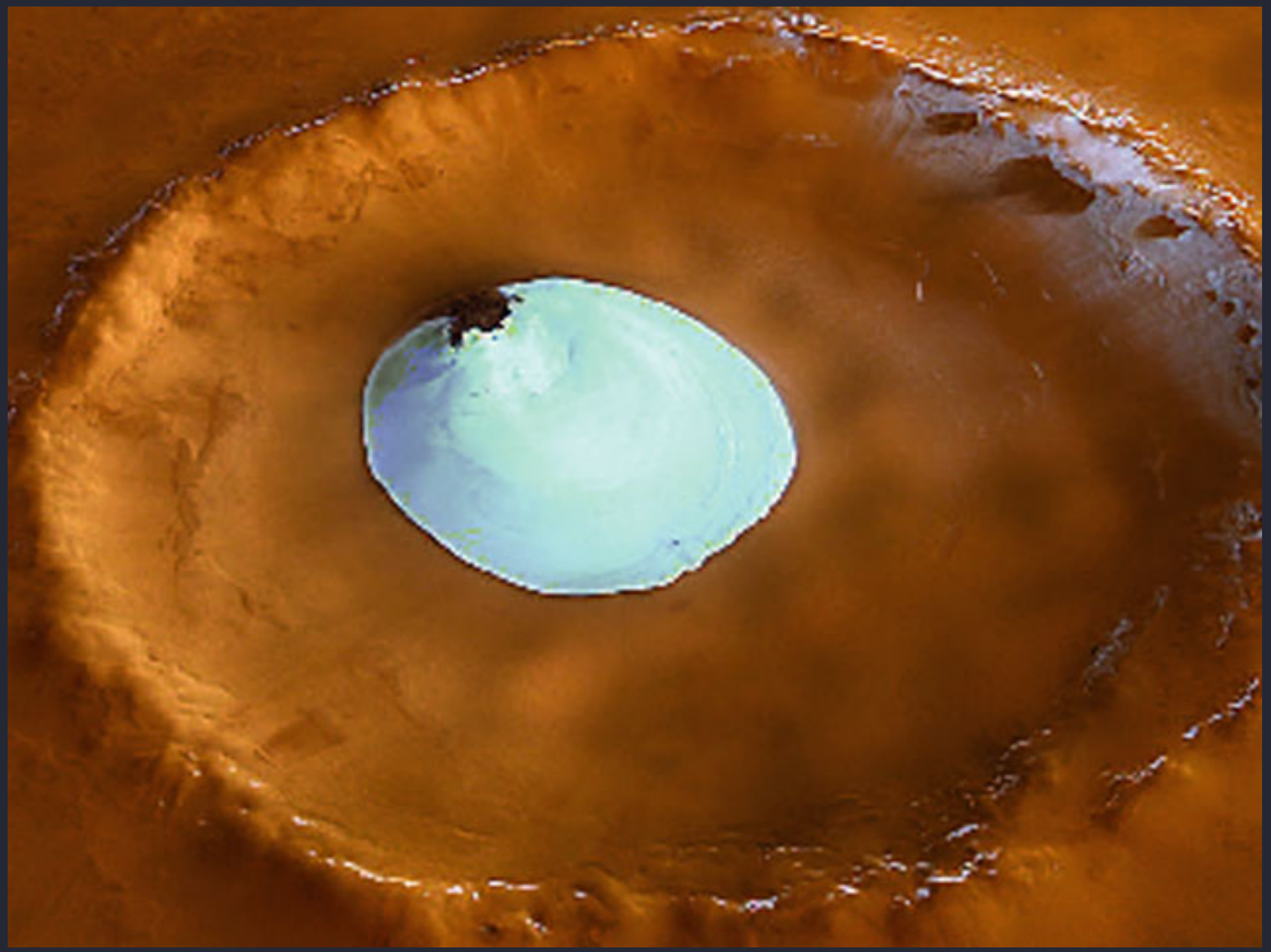
The "era of heavy bombardment" left Mercury (left) and the Moon (below) heavily cratered.



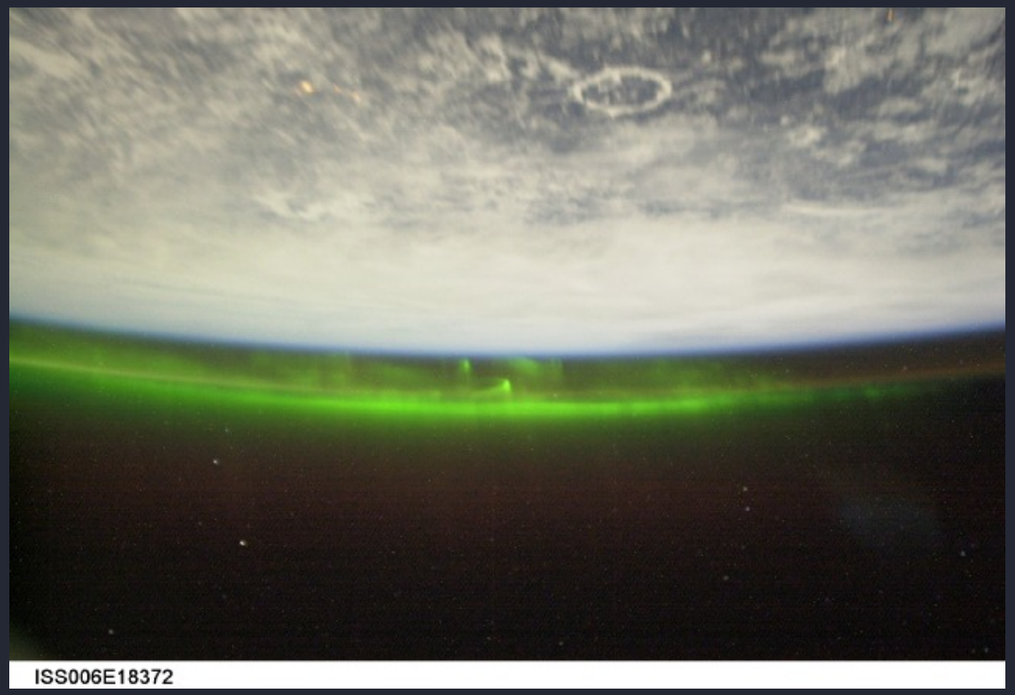
Saturn’s moon Mimas



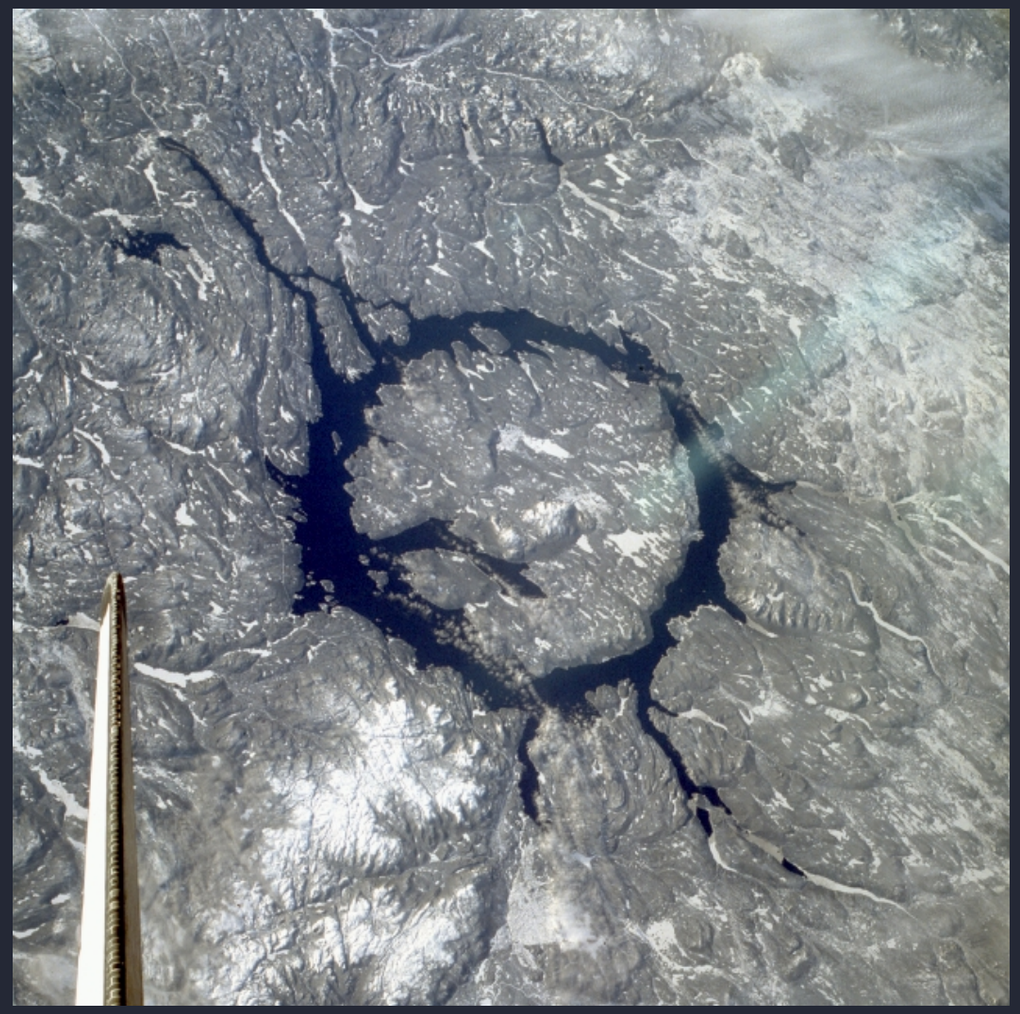
Martian crater with water-ice – did this water come from an earlier comet bombardment?



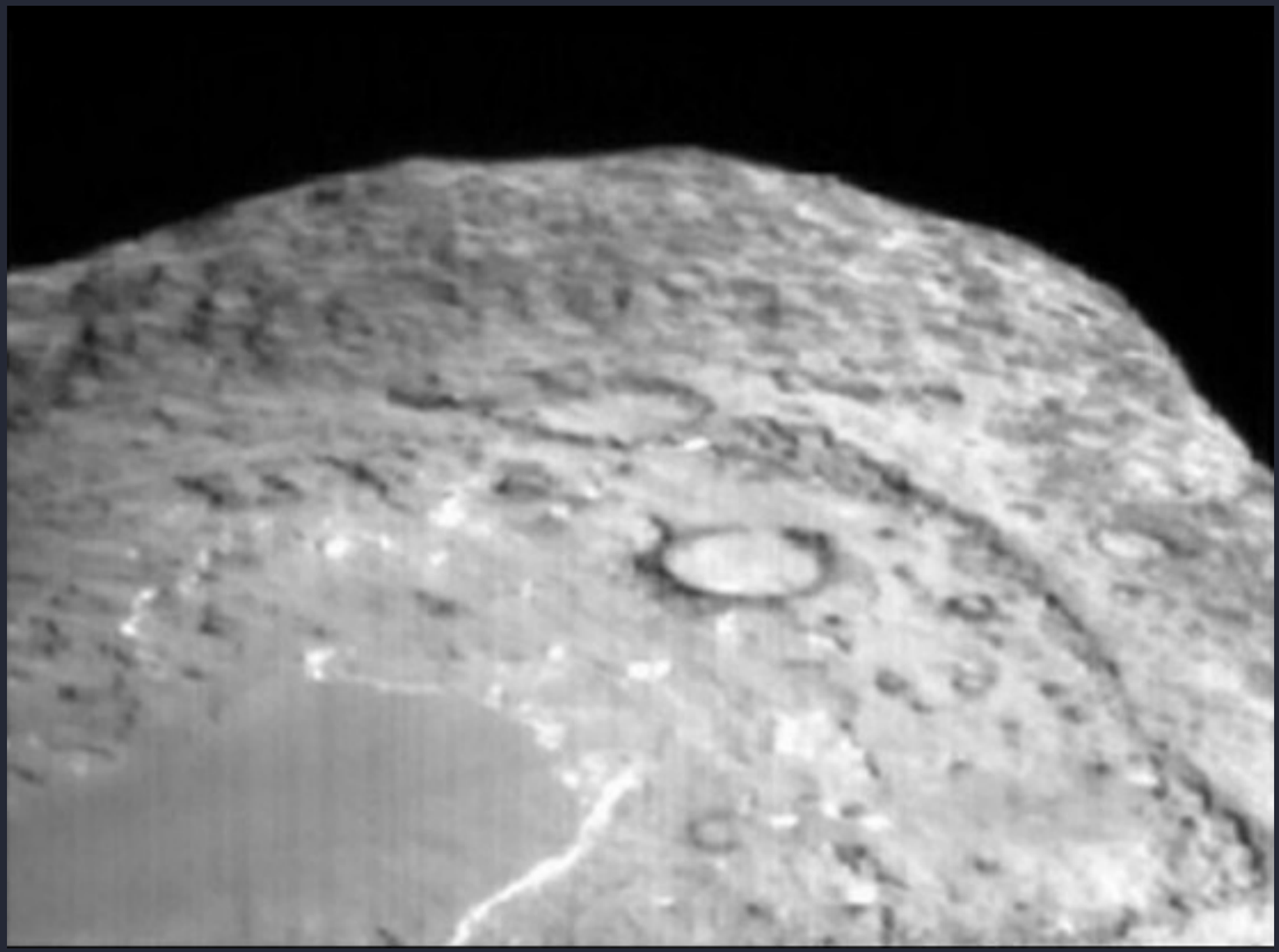
Earth has craters too, though erosion slowly destroys them. This one, in northern Canada, is old – 200 million years old.



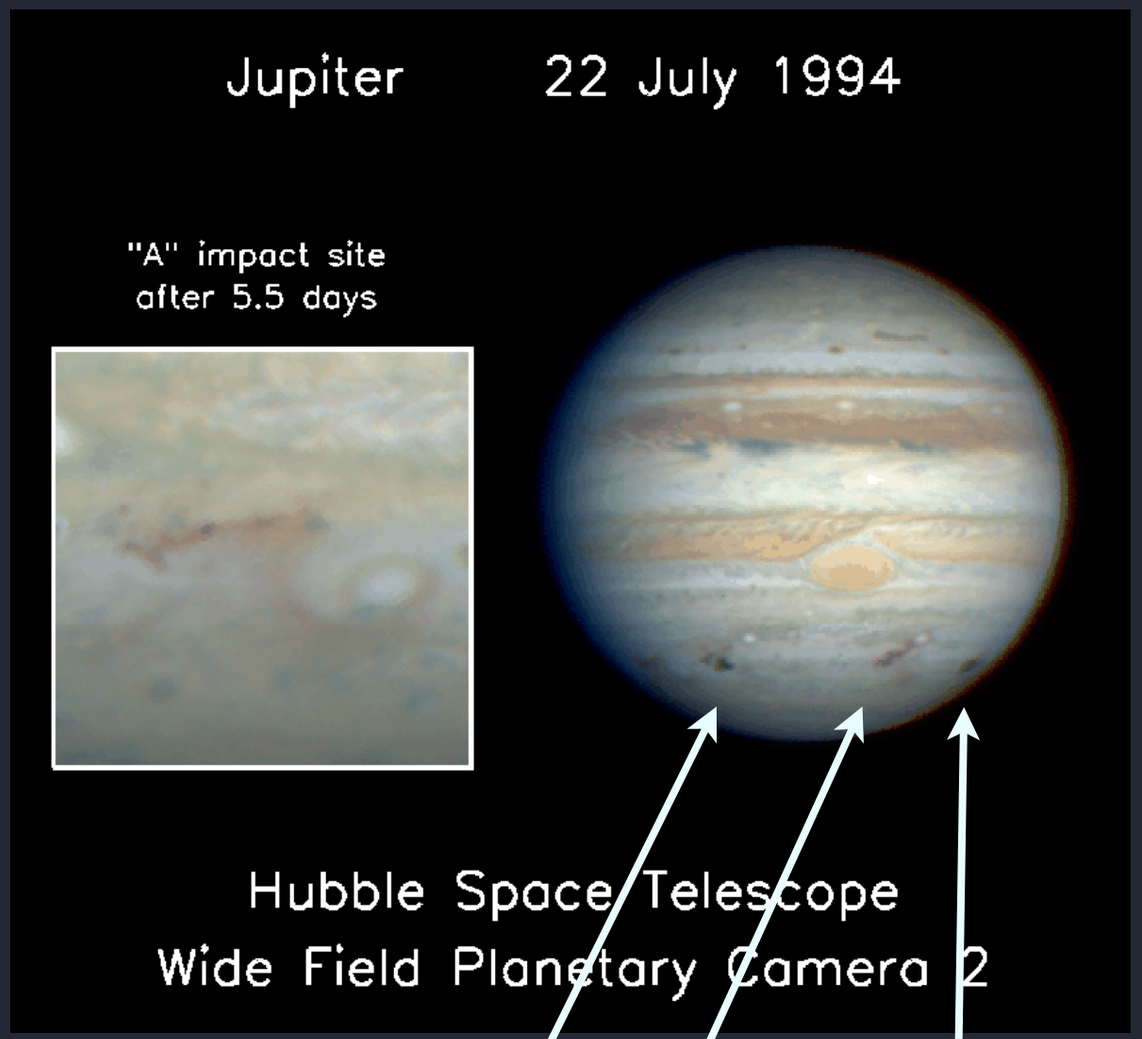
The green glow is the aurora borealis, or northern lights – the solar wind crashing into the upper atmosphere.

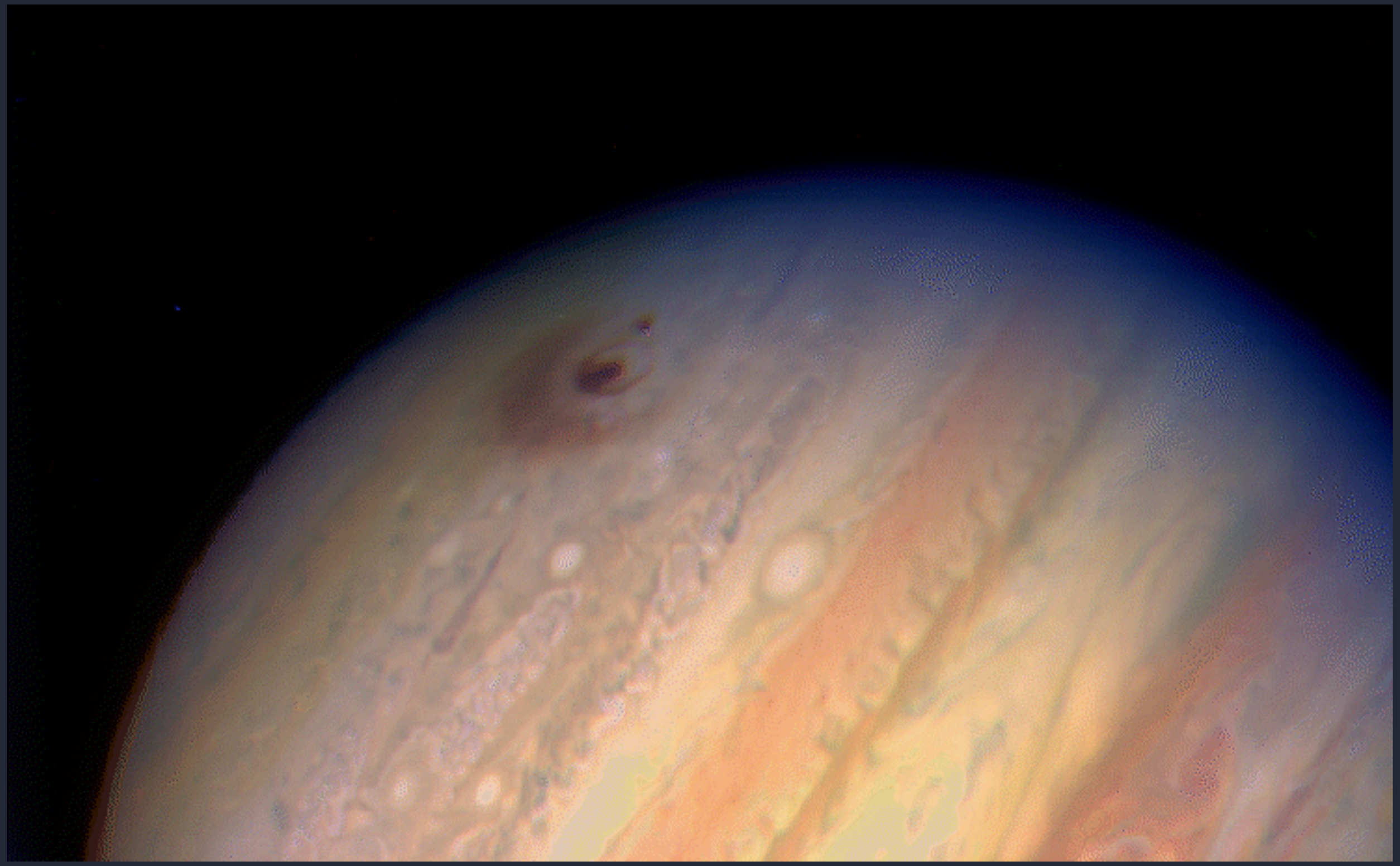


Comet Temple-1, a few dozen miles across…an icy planetessimal, has its own impact craters

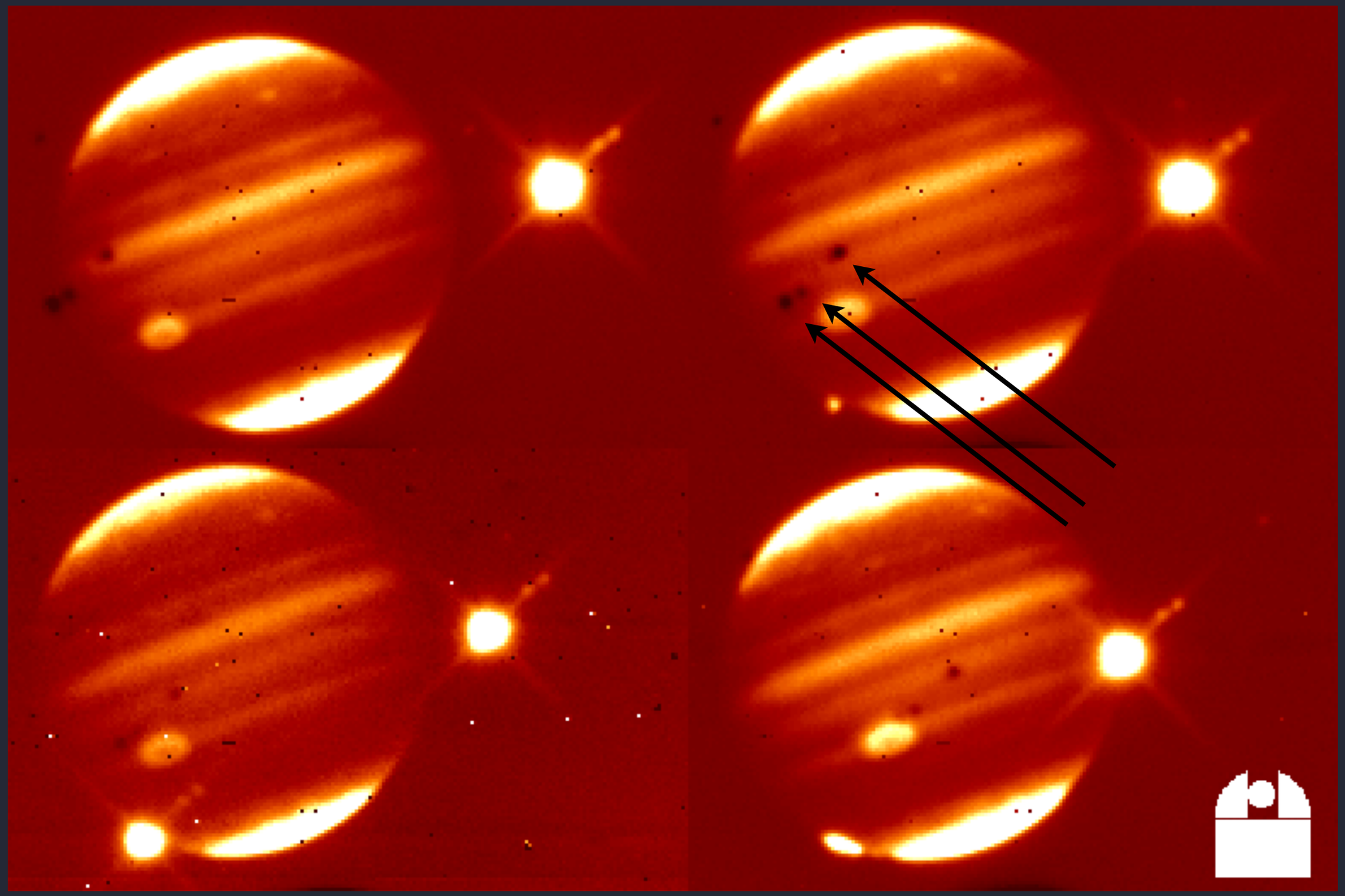


Big impacts can – and do – occur today. In 1994, comet Shoemaker-Levy crashed into Jupiter.





Infrared picture of the impact: holes made by the comet allow you to see into a deeper layer, which is cooler and dimmer



What does the nebular model explain?

4. Exceptions – Venus and Uranus's rotation, the Earth's moon, Pluto,…also some "ices" on the terrestrial planets (like water on the Earth)

the nebular theory predicts that soon after the formation of the solar system, the "left over" planetessimals were flying all around the solar system – perturbed by gravitational encounters with Jovian planets; this:

led to collisions in the inner solar system – tipping Venus over;
causing a large collision between a proto-planet and the Earth, which formed the moon;
"kicking" comets out into the Oort cloud;
delivering water, via comets, to the inner planets;

It also explains Pluto – Pluto is not a planet, but rather a large Kuiper belt object

Note that several other, Pluto-sized Kuiper belt objects have been discovered in the last few years – even bigger than Pluto and farther away from the Sun

A computer simulation of the impact of a Mars-sized object with the Earth

The color-coding represents temperature