Survey of the Solar System

The Sun

Giant Planets

Terrestrial Planets

Minor Planets

Satellite/Ring Systems

Satellites

All but two planets (Mercury & Venus) have satellites, as do several asteroids and minor planets

The giant planets have tens of satellites each

Have a broad spectrum of variability

Jupiter's Galilean moons

Satellites

Giant Planet Satellite Systems:

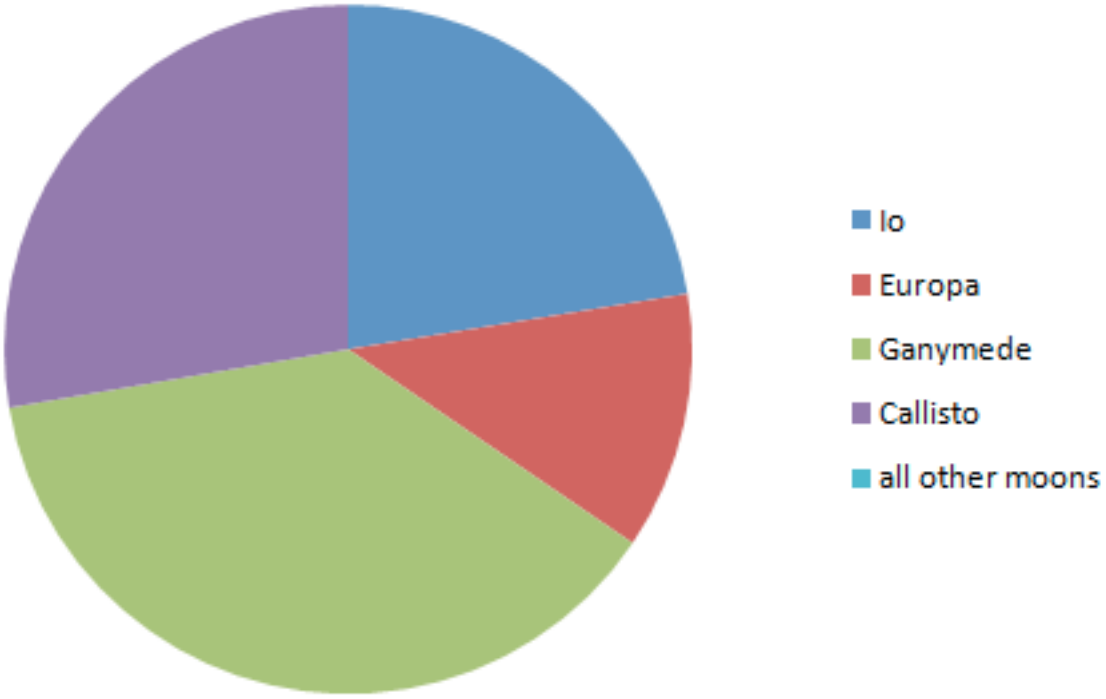
Tens of moons (J–67, S–62, U–27, N–14)

Inner moons in prograde orbits about planet and close to the equatorial plane with low eccentricity

Distant moons can orbit in any direction, at any inclination and with extreme eccentricity

Photo by Jan Sandberg

Not all moons carry equal weight…



Satellites

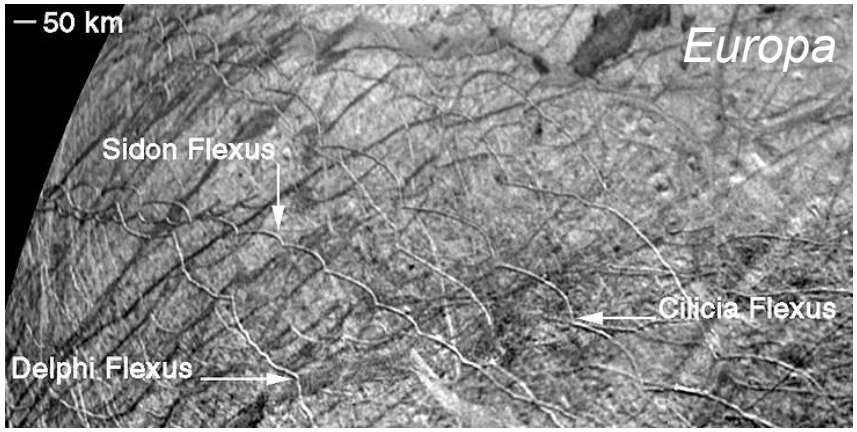
Giant Planet Satellite Systems:

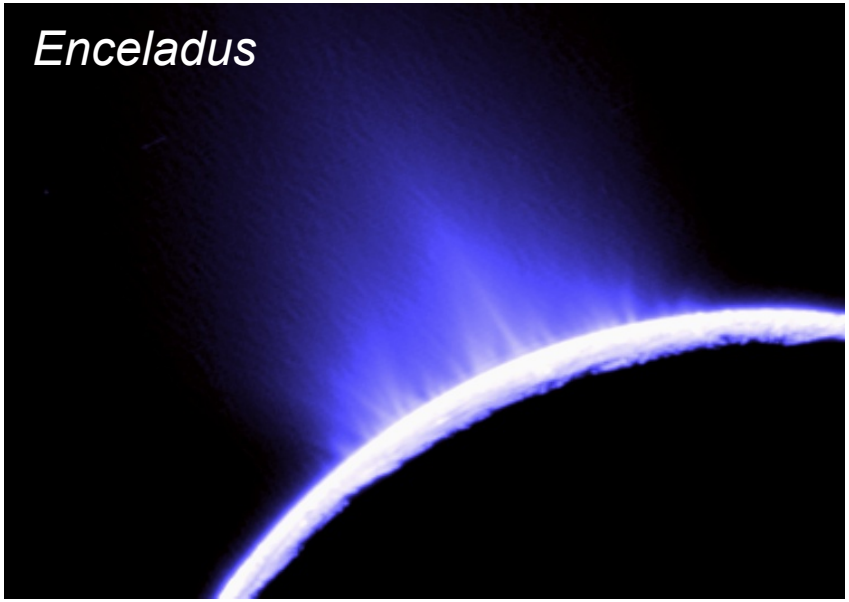
Tidal forces due to orbital eccentricity and changing gravity from other moons can generate significant interior heat for moons

Io [New Horizons]

Satellites

- Giant Planet Satellite Systems:
- Tidal heat could potentially be translated to driving volcanic activity, heating a subsurface layer, etc.



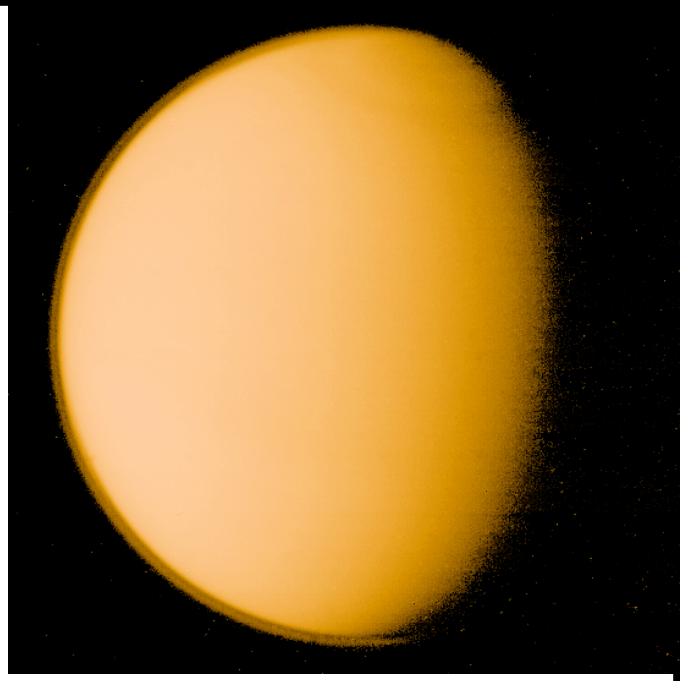


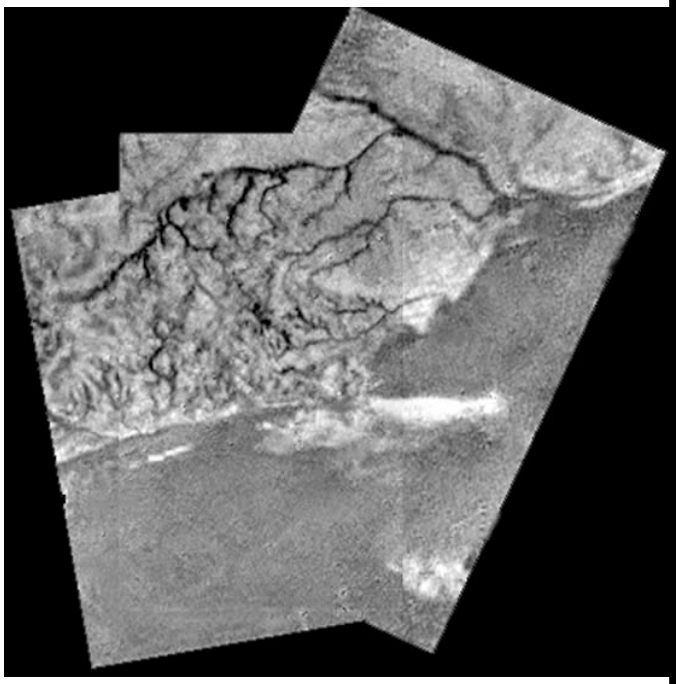
Satellites

Giant Planet Satellite Systems:

Diffuse atmospheres have been detected at several moons, including: Io, Ganymede, Enceladus

Titan's atmosphere is thicker than Earth's





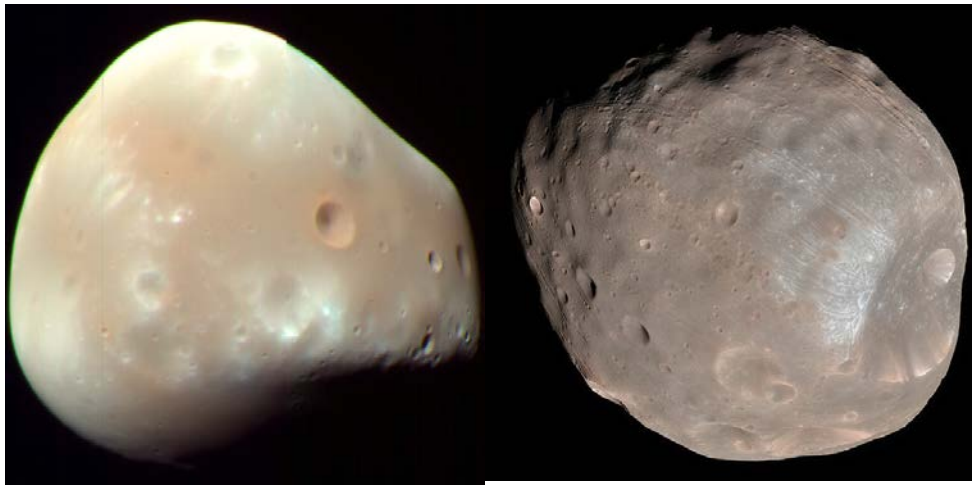
Satellites

Terrestrial Moons:

Earth's moon thought to be from a large impactor early in the solar system's history

Mars's two moons resemble asteroids; may be captured from the nearby Main Belt.

Deimos & Phobos from MRO



Satellite Sizes

Pluto and Earth have largest moons relative to their size; both are likely formed from the impact of secondary planetesimals

Ganymede and Titan are larger than Mercury

Smallest moons are ~ km in size

Earth and Moon from Messenger spacecraft

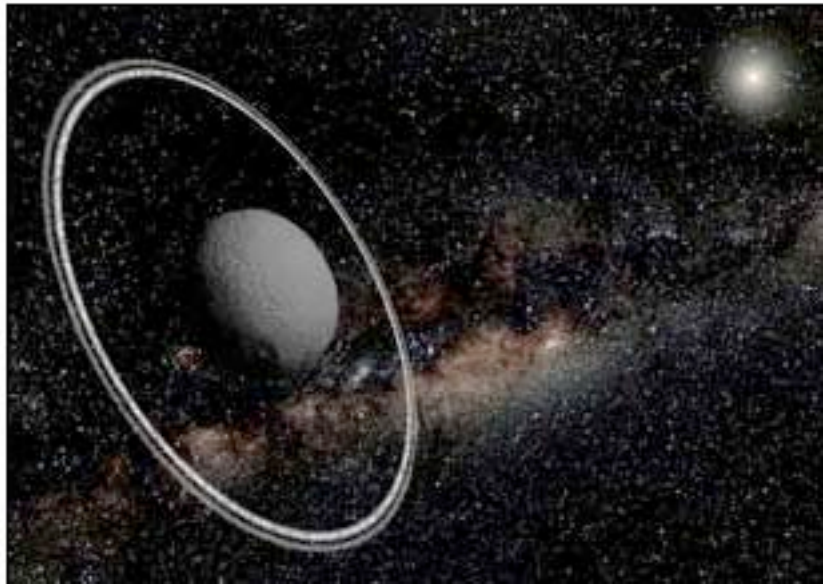
Ring Systems

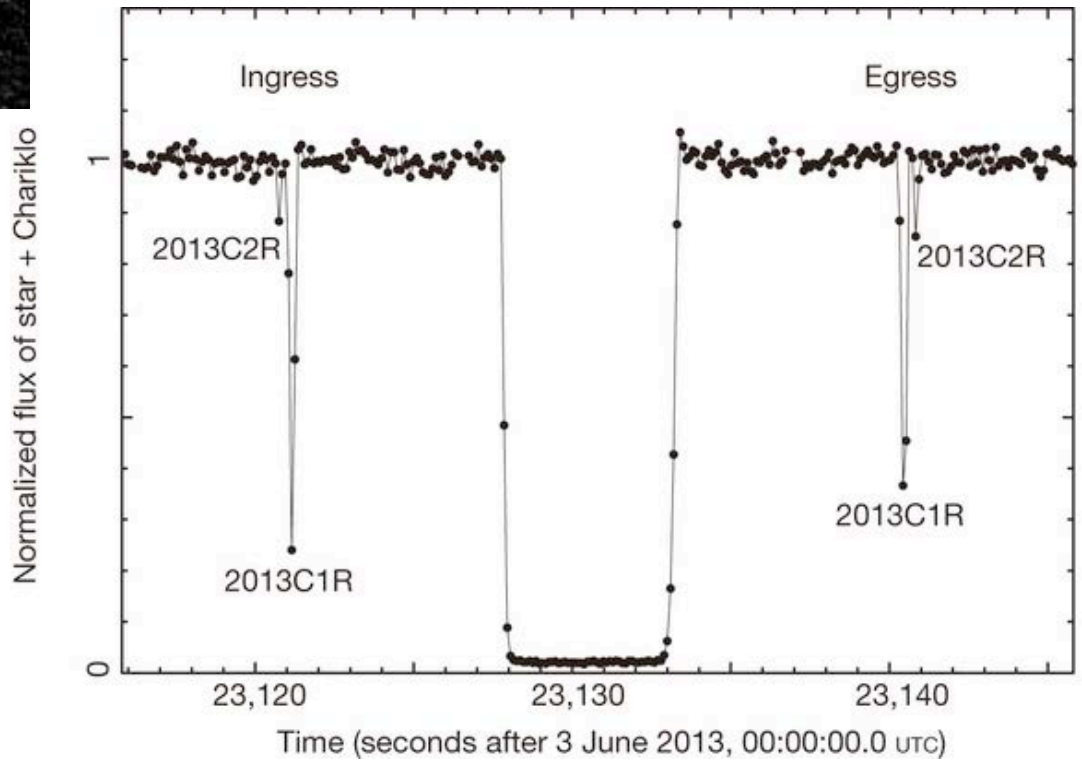
- Only giant planets* have confirmed ring systems

  **and asteroid Chariklo*

- Generally thought to reside within a few radii of the planet (but recent observations show otherwise!)
- Characteristics are quite variable between systems (e.g., Neptune arcs), raising many questions with respect to ring formation, life expectancy, and evolution.

Ring Systems – Chariklo! (largest centaur)





Ring Systems

Saturn:

Most observed and dynamic of the ring systems

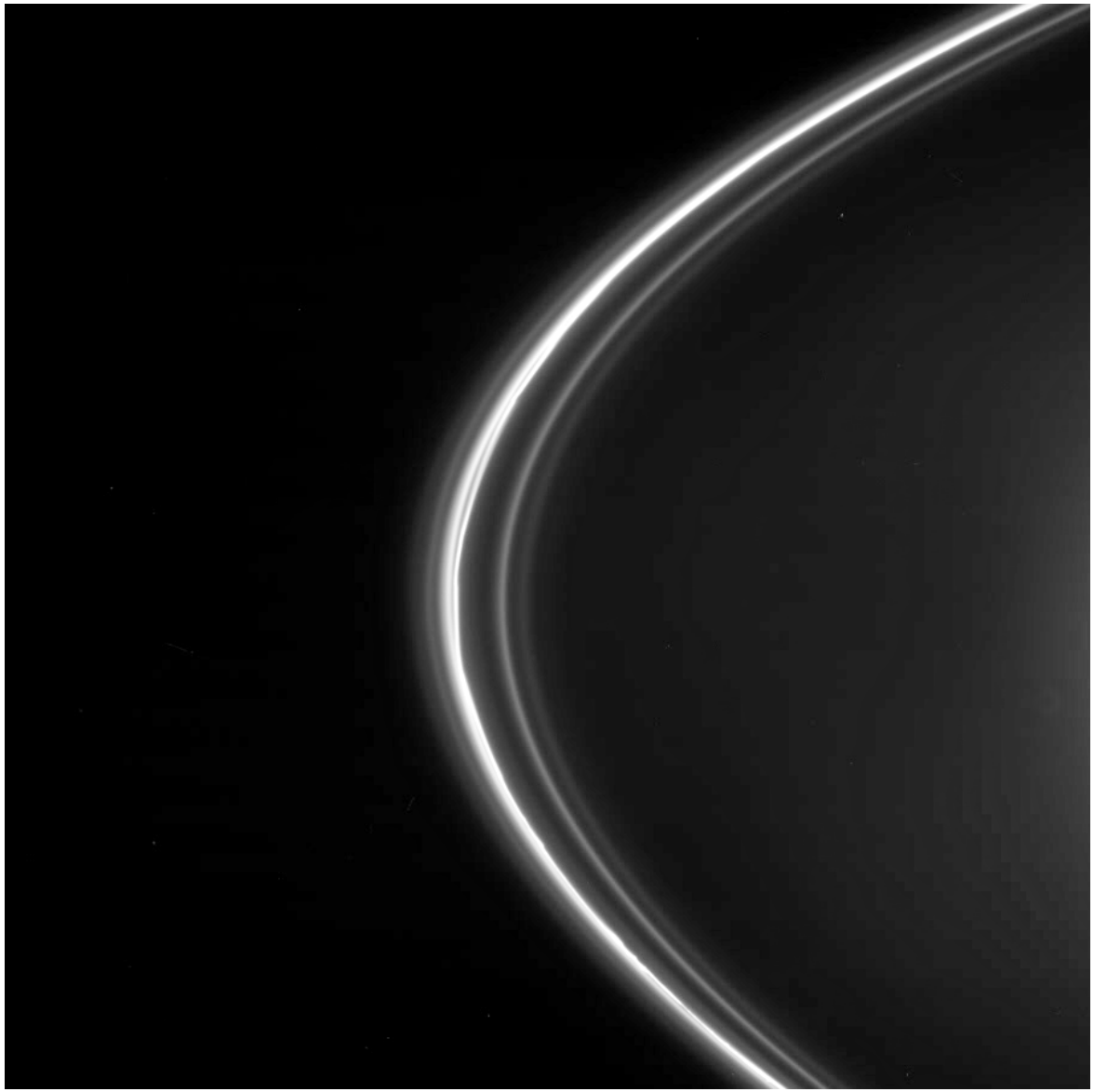
Ring particles are made nearly entirely of water ice, with some dust and other chemicals

Sun eclipsed by Saturn from Cassini

Ring Systems

Saturn:

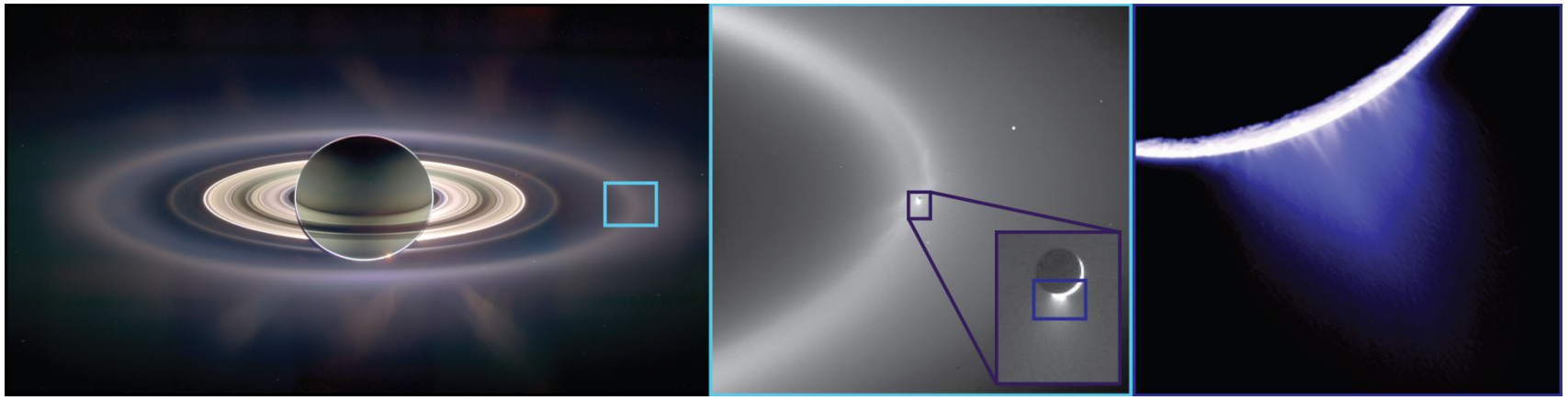
Rings dynamically shaped by moons causing waves, channels, gaps, etc.



Ring Systems

Saturn:

E Ring sourced from cryovolcanism on the moon Enceladus

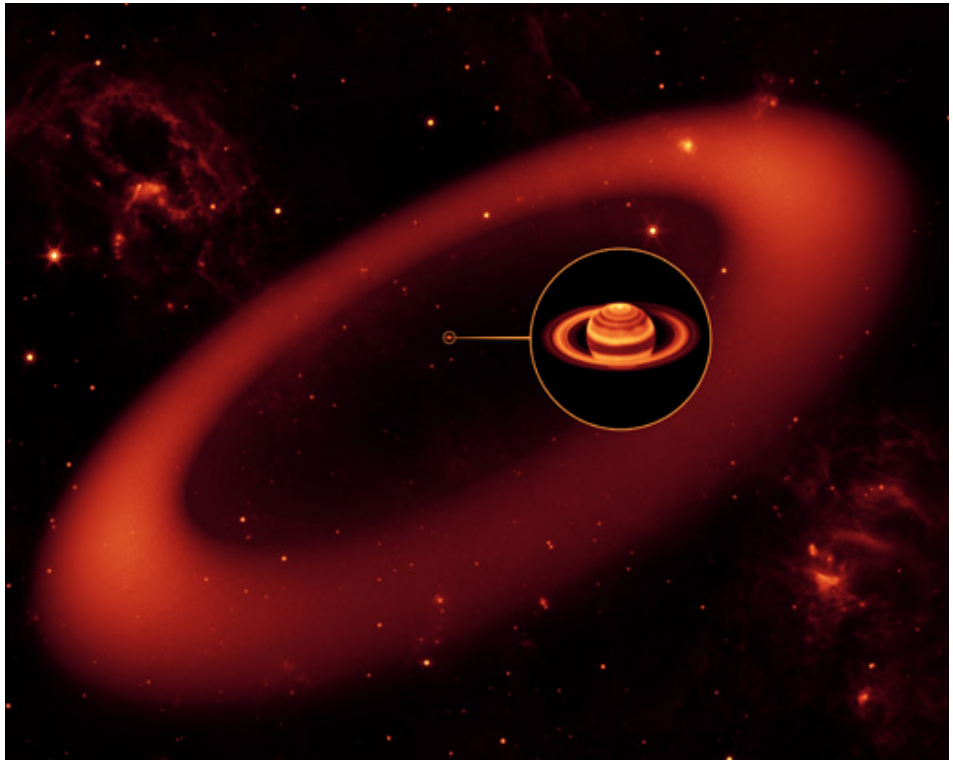


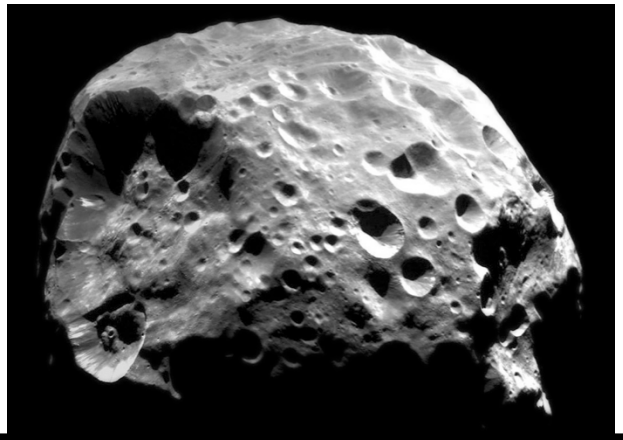
Ring Systems

Saturn:

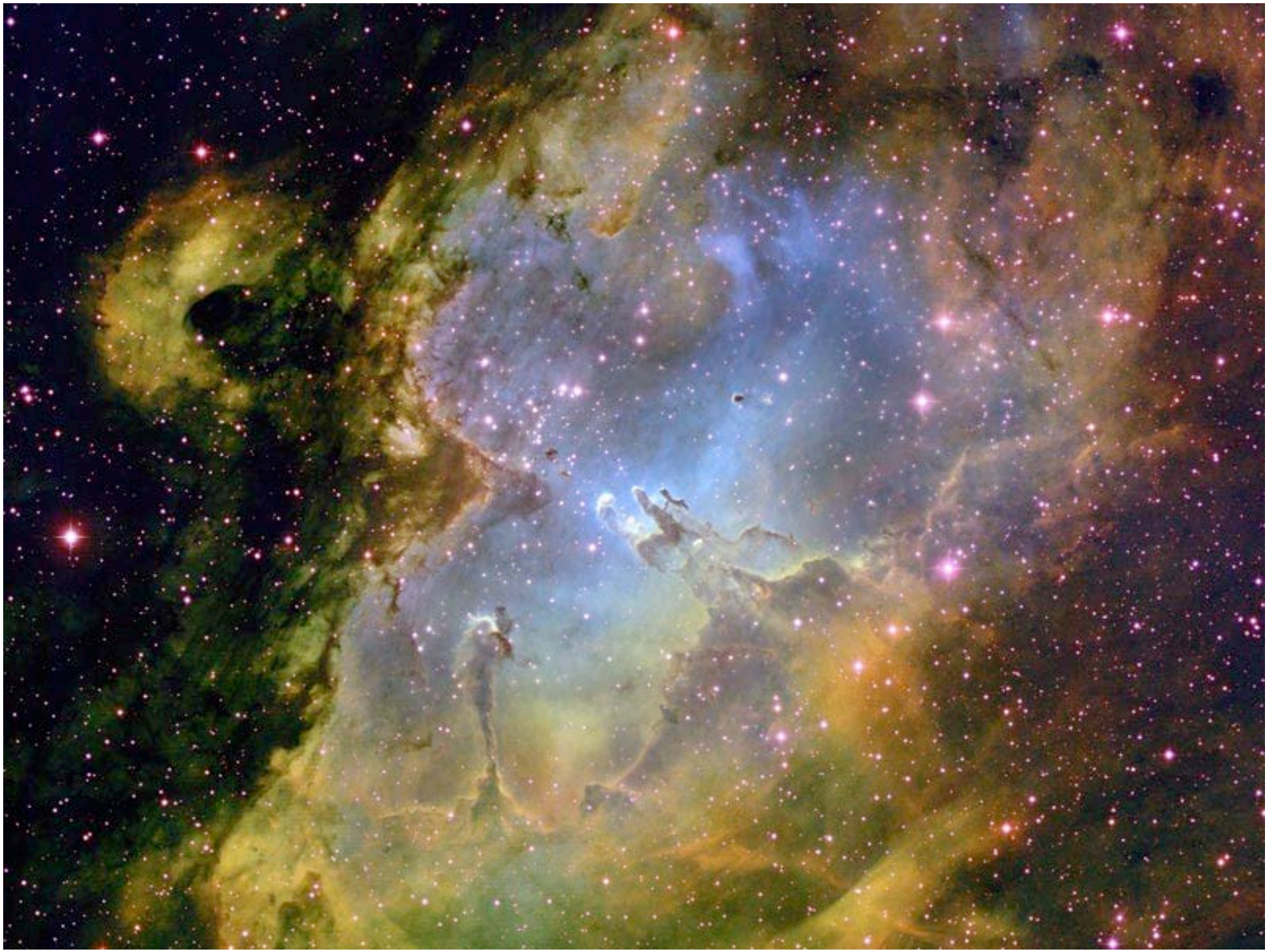
Latest ring discovery by Spitzer Space Telescope: ring orbiting at 100 R_s and tilted 27º from inner ring plane

Corresponds to orbit of irregular moon Phoebe





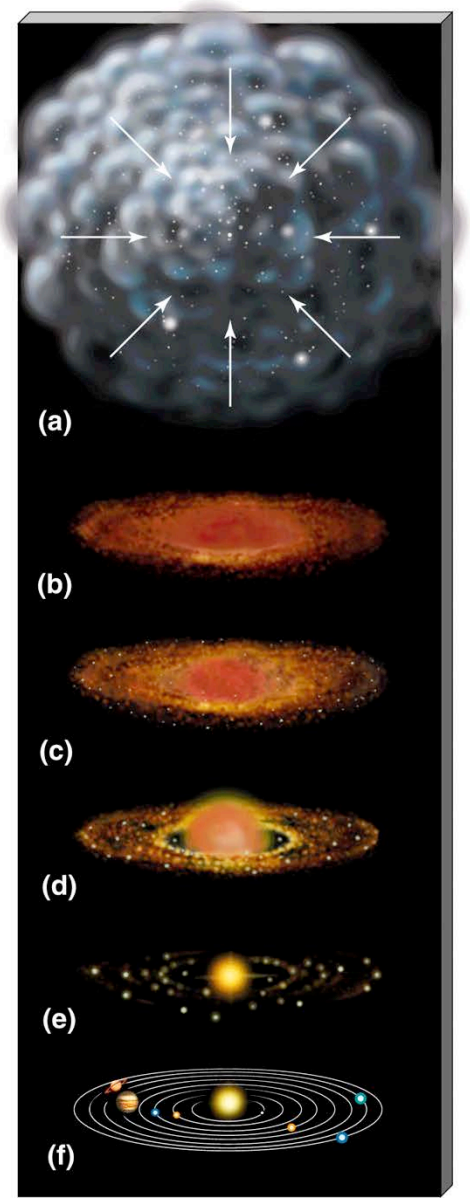
Solar System Formation in Brief



Solar System Formation: Constraints

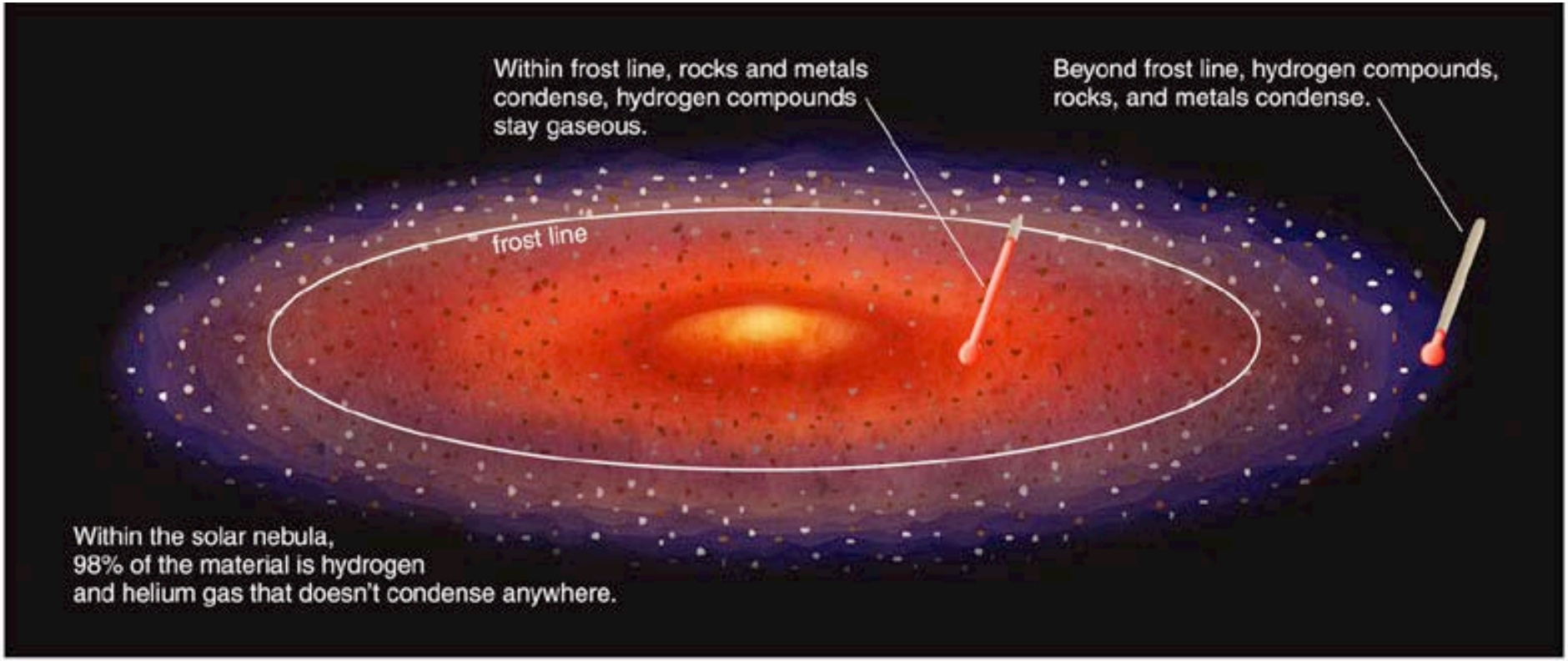
- Sun has 99.8% of mass, <2% of angular momentum
- Low inclination & eccentricity of planet orbits
- Most planets have low obliquity
- Large outer planets have ~solar composition
- Small inner planets enriched in heavy elements
- “Debris” in asteroid belt, Kuiper belt
- Meteorites have common age: ~4.6 Ga
- Oldest Moon rocks ~4.36 – 4.5 Ga

Solar System Formation in Brief



- Gravity leads to collapse of gas/dust cloud
- Initial net rotation → rotating disk
- Dust grains in disk collide, forming planetesimals
- Planetesimals collide and merge, forming planetary embryos
- Late collisions of embryos may have disproportionate influence
- Eventually, solar wind disperses unaccreted gas

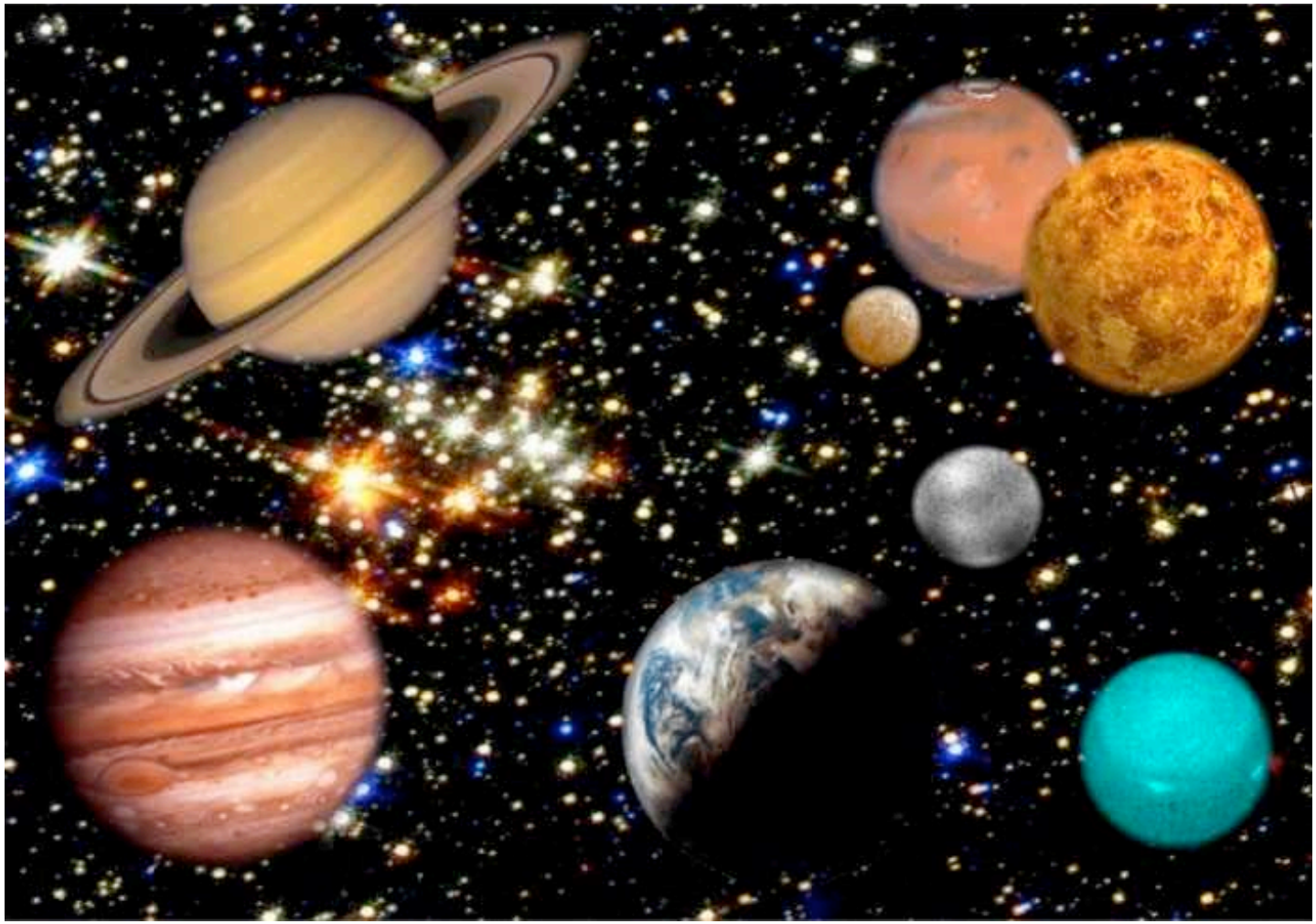
Solar System Formation in Brief



- Inner planets built from only rock and metals
- Outer solar system forms cores of ices+rocks+metals
- Sufficiently large cores accrete gaseous H and He

➔ Need to form these cores before the gas is blown away!

Solar System Formation in Brief



“These are some of the things that hydrogen atoms do given fifteen billion years of cosmic evolution.” —*C. Sagan*