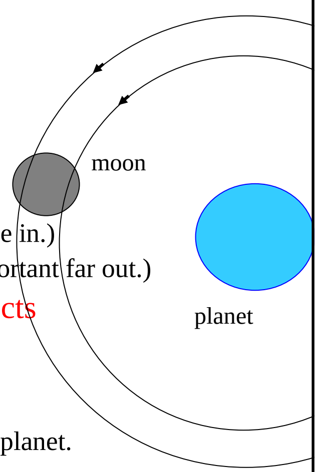
Jovian (Jupiter like) Planets

- Homework 4
  - Due Thurs, 26 Feb, 6:00am
- Test 2 is Tues, March 3rd.
  - Covers material through "terrestrial planets," 2/17
  - Large majority on solar system
  - A few question on topics covered in Test 1
  - Format same as Test 1. One cheat sheet.
  - Practice test: link on syllabus
  - Missouri Club is 7:00pm, Mon., March 2nd
- Summarizing Qs

1. What is the structure of Jupiter & how is it different from Earth's? Done
2. Why is the interior of Jupiter hot? Done
3. Why does Io, Jupiter's satellite have volcanoes? Done
4. Why are the inner moons irregular in shape and the big moons spherical? Done
5. Why do the Jovian planets have rings?

Roche limit



- For a moon in orbit around a planet,
  - $P^2 = a^3$ ➔ different parts of extended body have different orbital periods.
  - So body tends to be torn apart. (More important close in.)
  - But self-gravity tends to hold it together. (More important far out.)
- Roche's limit is where these two opposing effects are balanced:

$$\mathbf{R_{Roche} = 2.5\ (\rho_{planet}/\rho_{moon})^{1/3}\ R_{planet}}$$

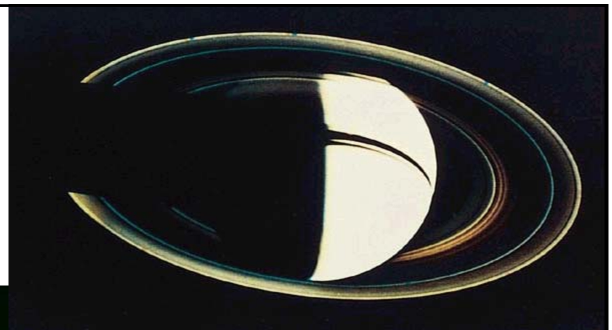
where ρ = density (kg/m^3) and R_{planet} = radius of planet.

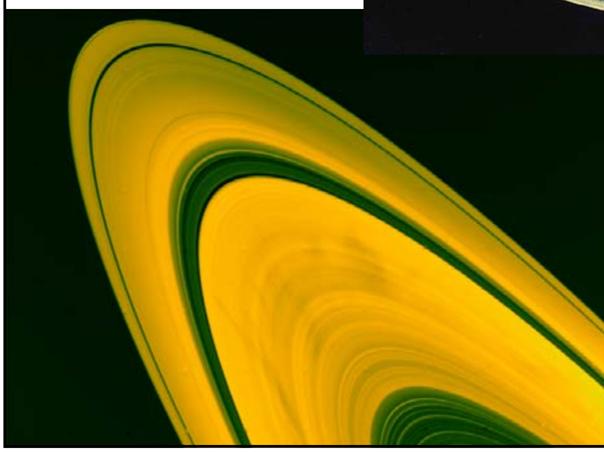
- If density of planet & moon are the same, then

$$\mathbf{R_{Roche} = 2.5\ R_{planet}}$$

Saturn's rings [12.6] top & bottom views

70,000 km wide, only 100m thick!





Bottom view, showing the light that is *not* reflected by the rings.

Note the Cassini division.

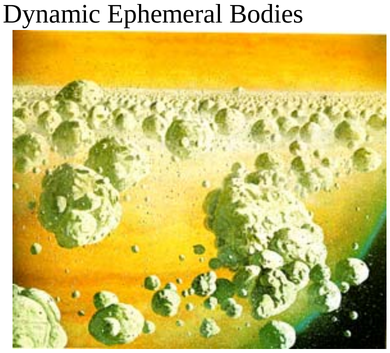
Color-enhanced top view, showing "spokes", of unknown origin.

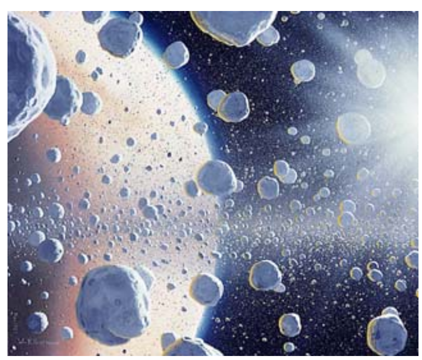
The Spoke Show

What are the rings made of?

Ice + dust.

Dynamic Ephemeral Bodies



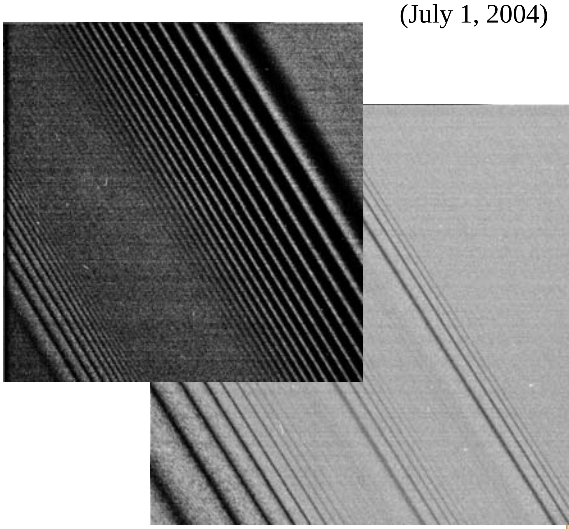


[Fig. 8.27]

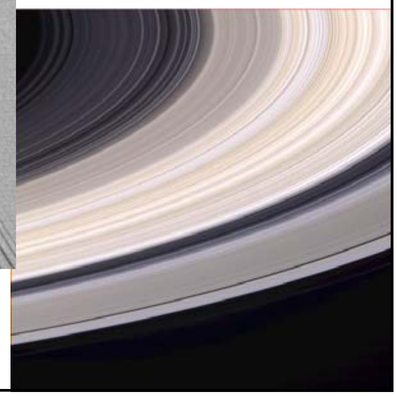
Rings only about 100m thick

Probe Cassini's passage through the rings

(July 1, 2004)

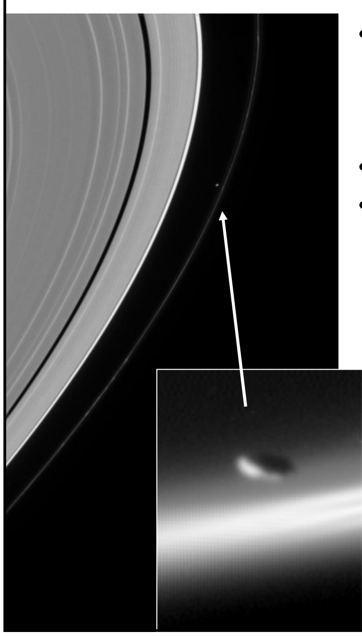


The "braided"
F ring.



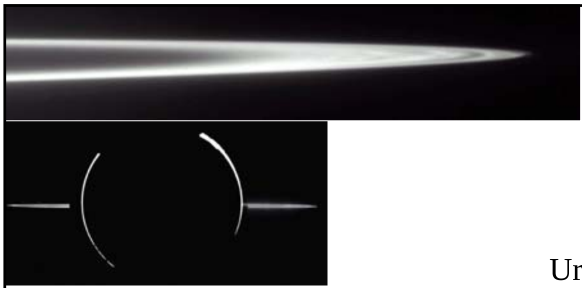
- Waves in the rings

Satellite-Ring Interactions



- Ring particles move according the Kepler's Laws except for the presence of moons.
  - The biggest force is gravity of planet
  - Moon add a tiny but important force.
- Many small moons found in rings.
- Their gravitational interaction shapes the rings:
  - "Gap moons" pull on particles and disrupt their orbits. Cause gaps in rings.
  - Pairs of moons can "shepherd" rings particles together.
- Bigger moons cause large gaps.
  - For particles at a certain location, on every other orbit, Mimas is in the same position. Mimas pulls the same way and clears out the particles from that position. There is no material in the "Cassini" division.

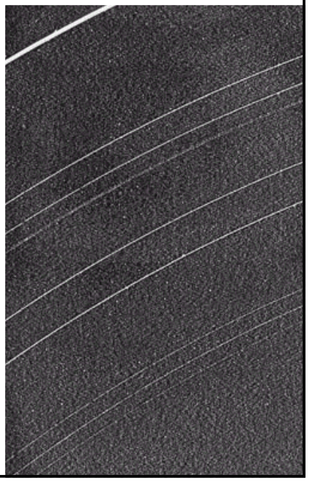
Prometheus (102 km long)
+ part of a ring

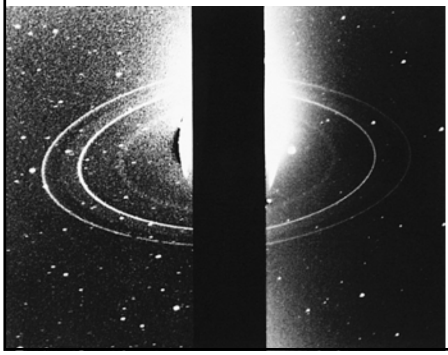


All 4 Jovian planets have rings

Jupiter's ring
Imaged by Voyager & Galileo

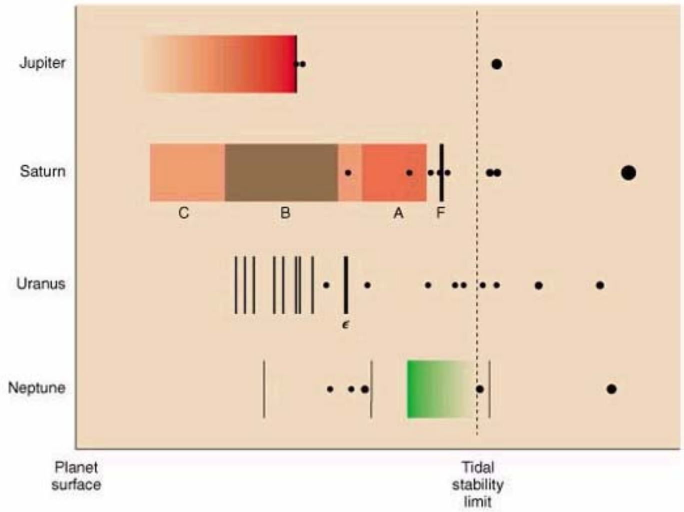
Uranus
[see Fig 8.29]





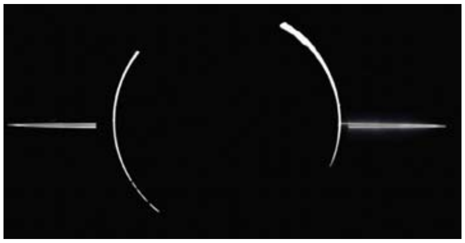
Neptune
[Fig 8.29]

Location of the rings (Dots are moons. Lines & bands are rings.)



(Roche limit)

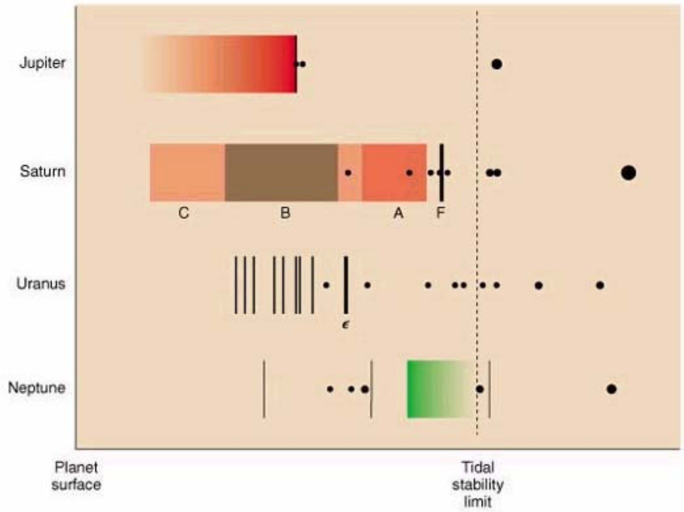
4. The large moons were made by collecting smaller moons. Why can't the material in the rings collect to form large moons?
    a. There is not enough material
    b. The rings are too thin
    c. The gravity of the planet would tear the moon apart.
    d. The rings are not made of sticky material



Roche's limit and the Rings

Large objects cannot form in this region,

or get broken up even if they do form.



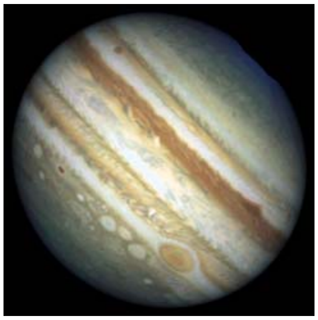
(Roche limit)

Formation of the Solar System

- Questions
  - Why are rocky planets close to the sun?
  - Why is solar system a disk?
  - How did the planets form?
  - Asteroids
  - Meteorites—"fossils" from the birth of the solar system
  - How old is the solar system?

Terrestrial & Jovian Planets

- Why are the planets near the sun dense (rock) and the farther planets less dense (like water)?

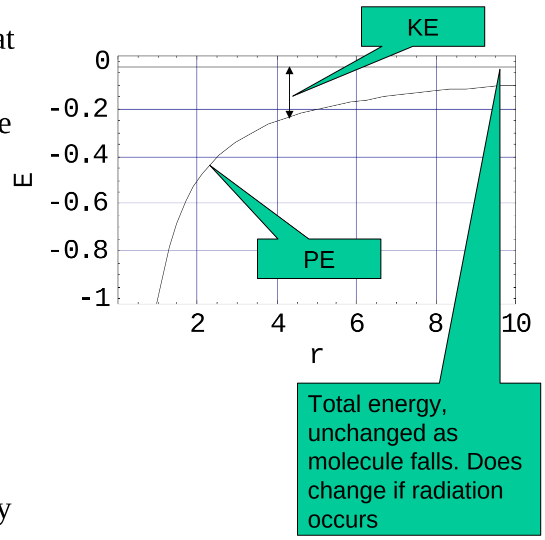


Jupiter;
1.3 gm/cm3

Mercury;
5.4 gm/cm3

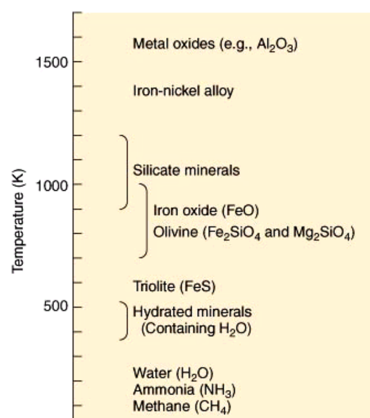
Collapse of the Protosolar Cloud
Thermal history of the Solar System

- I am a hydrogen molecule in the cloud that will become the sun.
- My energy is kinetic (due to motion) and potential (due to gravity).
  - Energy = KE + PE
  - KE is proportional to v^2
  - PE depends on distance r to center of cloud
- When I fall from r = 30 AU (Neptune) to r = 1 AU (Earth), my KE (and temperature) increases by a factor 30.

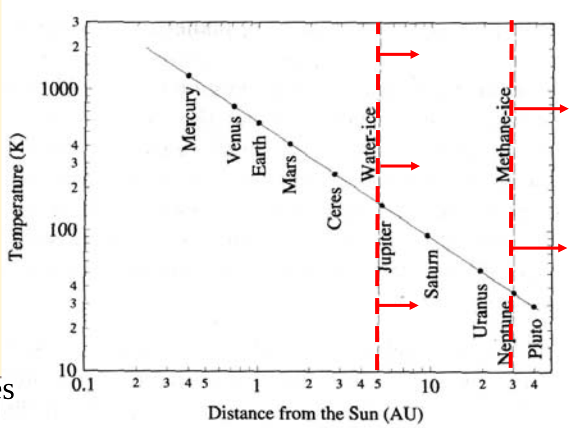


Thermal history of the Solar System

- When I fall from r = 30 AU (Neptune) to r = 1 AU (Earth), my KE (and temperature) increases by a factor 30.
- If temperature of material falling to Nepture is 30K, the temperature of material falling to 1 AU is 900K. Temperature of plot is not so steep. Material cools too.
- Q: Can SiO2 (sand) and water condense at 1AU when Earth formed? A: YY, B: YN, C: NY, D:NN
- Same question for Uranus



Evaporation Temperatures



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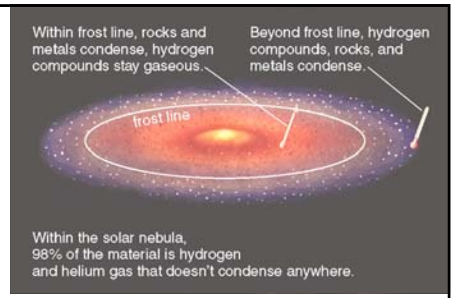
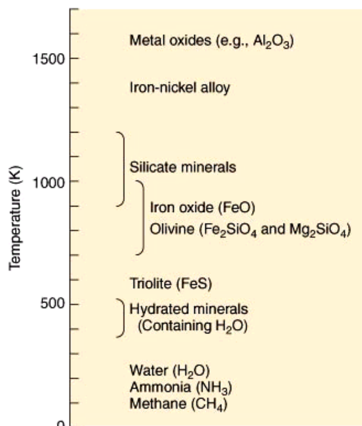


[Fig. 6.20]



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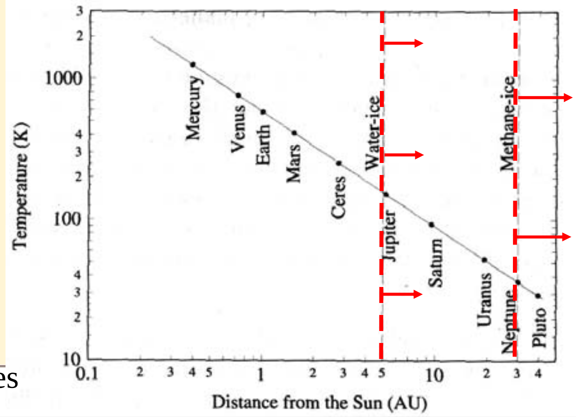
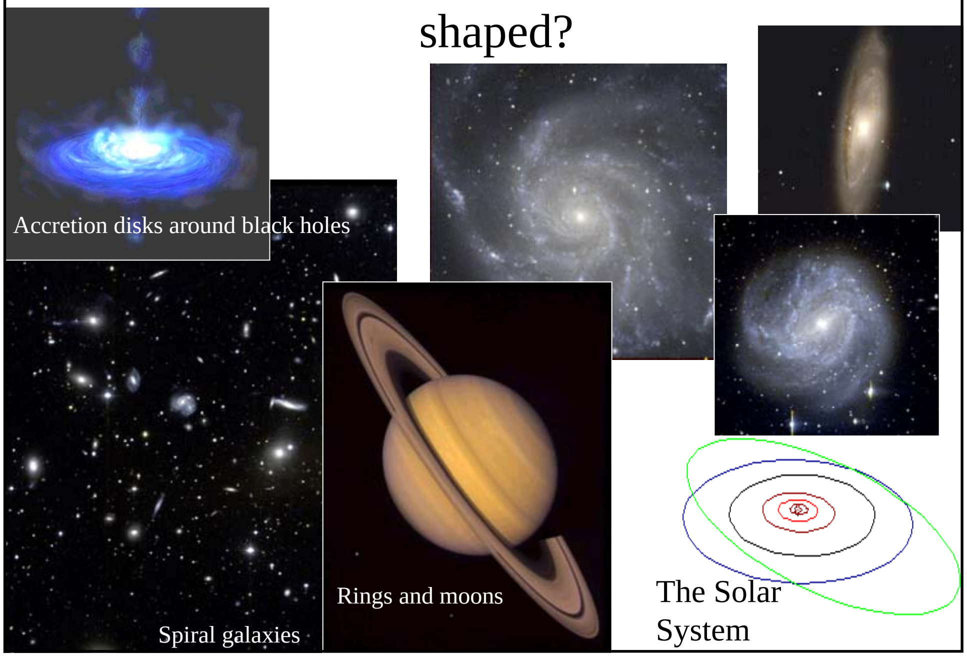


Giants vs. Terrestrials

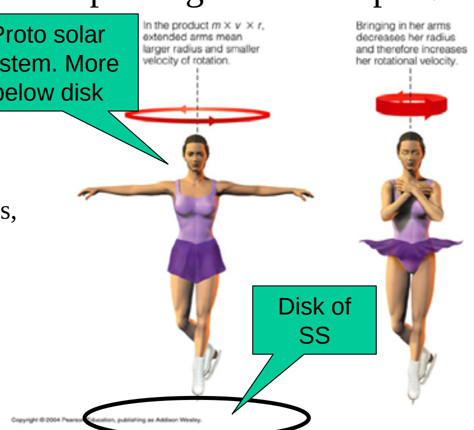
- Inner solar system
  - Lighter elements evaporated away.
  - Planetesimals contained only heavy elements.
  - Growth stopped at Earth-sized planets.
  - Continuing impacts with planetesimals altered the planets
    - Earth's moon
    - Reversal of Venus' rotation, etc.
    - Dumped much of atmospheres onto planets
- Outer solar system
  - Ices as well as silicates available for solid bodies.
  - Larger protoplanets resulted.
  - These cores able to attract surrounding H & He gas in order to build giant planets.
  - Gravitational field of giant planets perturbed orbits of remaining planetesimals.
    - Most comets ejected into Oort Cloud

Why is the solar system spinning & disk shaped?



Why is the solar system spinning & disk shaped?

- Skater represents protosolar system
- Kepler's Law of Equal Areas, Conservation of Angular Momentum:
  - L = m r v
  - r is distance to rotation axis, measured perpendicular to rotation axis
  - v is speed of rotating motion
- If skater pulls arms in (cloud shrinks horizontally), skater spins faster.



- Q: If skater floats down (cloud collapses toward disk), skater spins a) faster, b) same, c) slower
- Q: If material falls toward sun, material spins___. Same foils.

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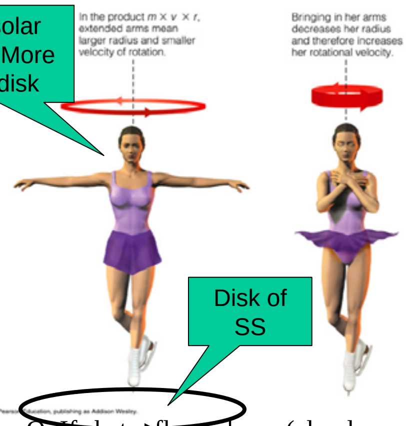

- Skater represents protosolar system
- Conservation of Angular Momentum
  - $L = m\ r\ v$
  - r is distance to rotation axis
  - v is speed of rotating motion
- If cloud shrinks toward axis (horizontally), cloud spins faster.
  - Real cloud can only spin so fast because gravity must hold gas in orbit.
- Cloud can shrink along spin axis without butting against angular momentum. Cloud can flatten.

- Q: If skater floats down (cloud collapses toward disk), skater spins a) faster, b) same, c) slower
- Q: If material falls toward sun, material spins___. Same foils.