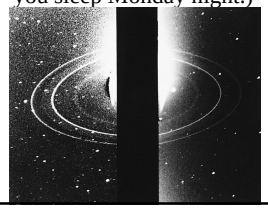
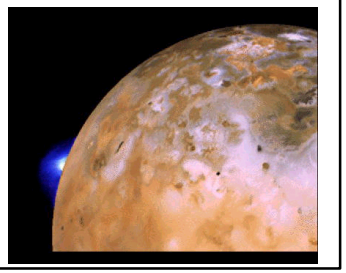
Moons & Rings–February 18

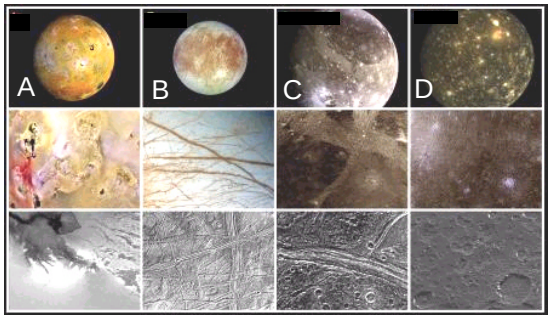
- Two loaner clickers
  - Borrow them for the class
  - Does not count against the two times you may turn in paper answers.
- Homework closes at 3am on Tues. (Finish before you sleep Monday night.)



- Galilean Moons of Jupiter
- Rings of the Jovian planets

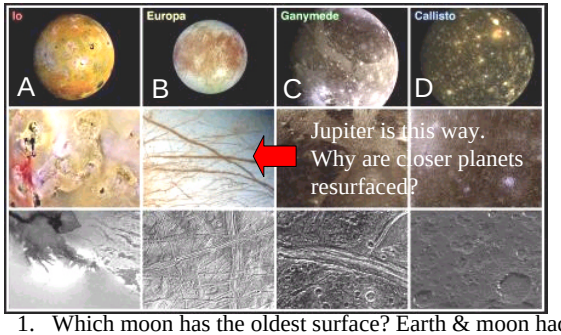


Moons of Jupiter – Age of Surface



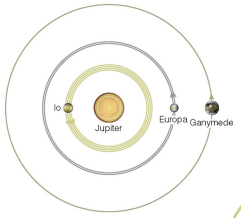
1. Which moon has the oldest surface? [Do not look in your book. Examine the pictures & deduce the answer.] [Hint: Compare the appearance of surfaces of earth & moon.]

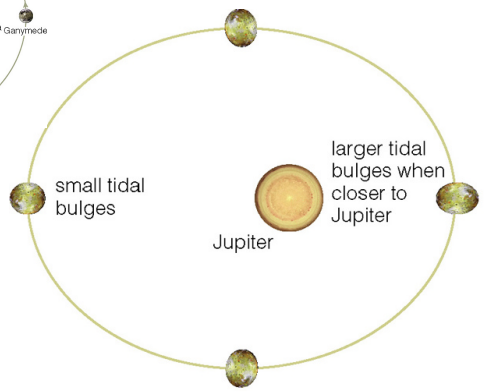
Moons of Jupiter – Age of Surface



1. Which moon has the oldest surface? Earth & moon had similar number of meteors. Craters on earth have been erased by weathering & tectonics. Answer: Callisto (D)

Tidal Heating of Jupiter's Galilean Moons

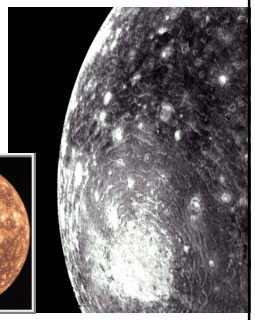


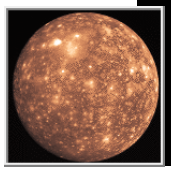


[Fig. 8.15]

	Diameter (km)	Relative Mass	Density (g/cm^3)	% Reflectivity
Moon	3476	1.0	3.3	12
Callisto	4820	1.5	1.8	20
Ganymede	5270	2.0	1.9	40
Europa	3130	0.7	3.0	70
Io	3640	1.2	3.5	60

Callisto

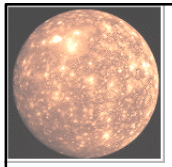




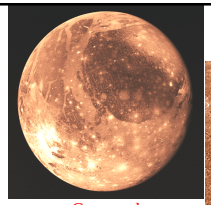
Callisto

- Orbital period: 17 days
- Tidal locking with Jupiter
- Surface temperature = -140° C
  - appears to be mostly ice.
  - 1.8 x density of water
- Many impact craters.
- Not well differentiated
  - Close Galileo flybys ➔ gravitational field ➔ no dense core.
- Geologically dead for 4 billion yrs.

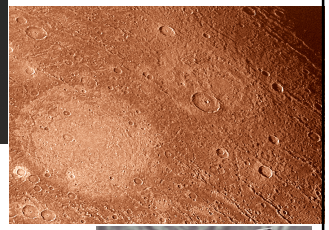
Ganymede



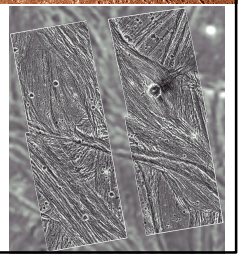
Callisto



Ganymede

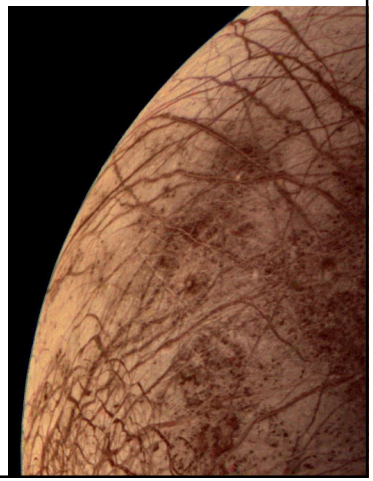


- Largest satellite in Solar System
- Fewer impact craters than Callisto ➔ geologically active.
- Differentiated
  - Rock, metal core.
    - Magnetic field present.
- Mantle, crust made of ice
  - Volcanic flows, but water rather than lava.
  - Ridges, valleys due to compression of crust.

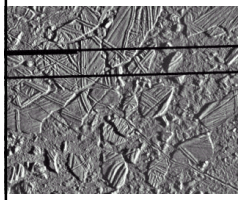


Europa

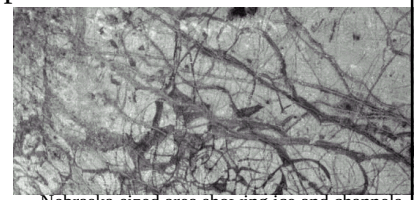
- *Not* made of ice.
  - Density similar to Moon
- Tidal forces keep it geologically active.
- Covered by layer of water ice.
  - Appears to be "pack ice" on top of an ocean.
  - Water must be warmed by heat from Europa's interior.



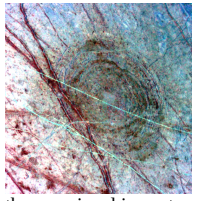
Europa's surface



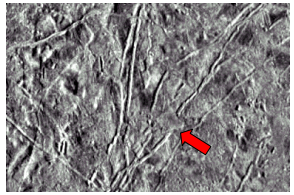
Ice rafts



Nebraska-sized area showing ice and channels.



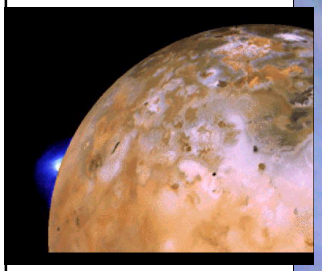
+ the occasional impact crater

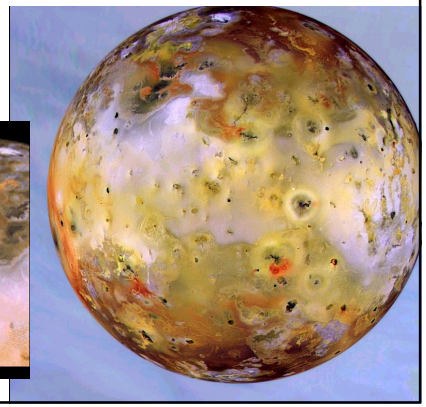


Ice flow cutting across ridge

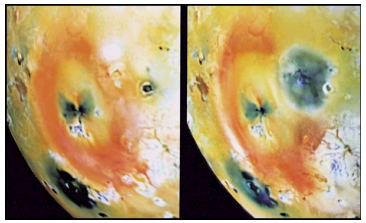
Io

- Closest to Jupiter (of Galilean Satellites)
  - Strongest tidal forces.
- Active volcanoes
  - hot silicate lava, similar to Earth.

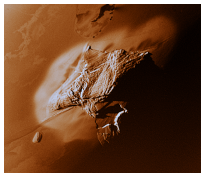




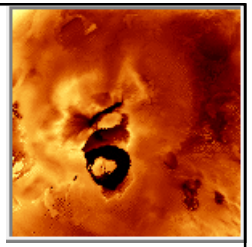
More Io



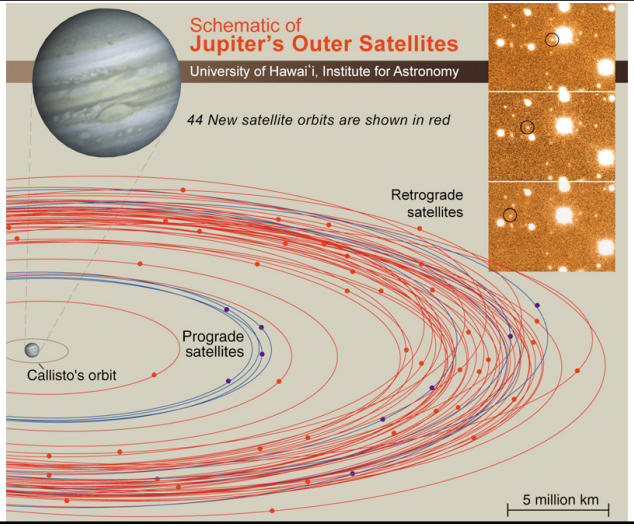
Images of same region, 5 months apart.



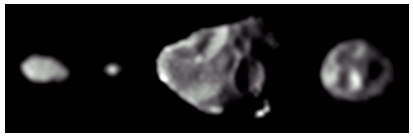
Haemus Mons - a volcanic cone



Loki Patera
Thought to be a liquid sulphur lake with a solid sulpher raft.

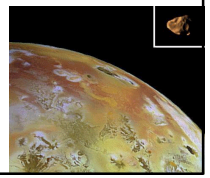


The Innermost Moons of Jupiter



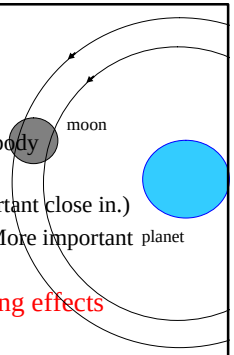
Metis Adrastea Amalthea Thebe

2. What holds a yardstick together?
   a. Gravity
   b. Atomic bonds between the atoms
3. What holds Io & Metis together?
   a. Gravity for both
   b. Bonds for both
   c. Gravity for Io; bonds for Metis
   d. Gravity for Metis; bonds for Io



Amalthea & Io

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:

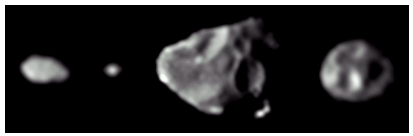
$$\mathbf{R_{Roche} = 2.5\ (r_{planet}/r_{moon})^{1/3}\ R_{planet}}$$

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

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

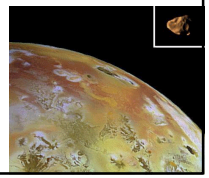
$$\mathbf{R_{Roche} = 2.5\ R_{planet}}$$

The Innermost Moons of Jupiter



	Metis	Adrastea	Amalthea	Thebe	(Io)
Size (km)	40	20	270x166x150	116	3630
Mass (kg)	10^{17}	$2x10^{16}$	$7x10^{18}$	$7x10^{17}$	$9x10^{22}$
Orbit radius (km)	128,000	129,000	181,000	222,000	422,000

Inside Jupiter's "Roche limit".

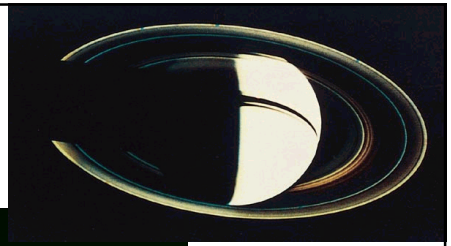


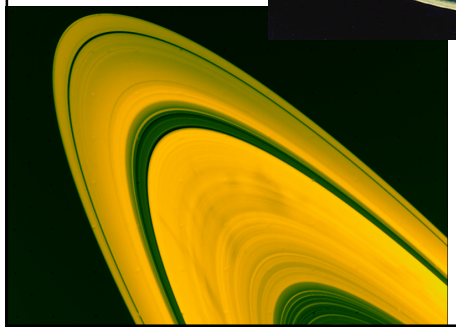
Amalthea & Io

Saturn's rings [12.6]

top & bottom views

70,000 km wide, only 100m thick!



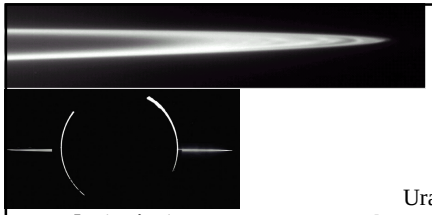


Bottom view, showing the light that is *not* reflected by the rings.

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

The Spoke Show

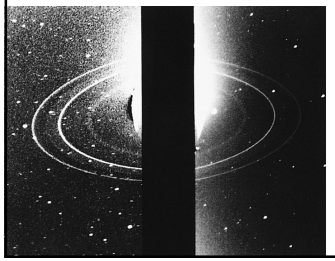
All 4 Jovian planets have rings



Jupiter's ring

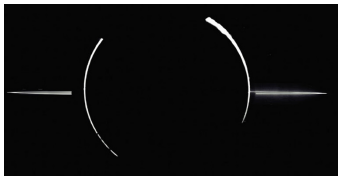
Imaged by Voyager & Galileo

Uranus [see Fig 8.29]



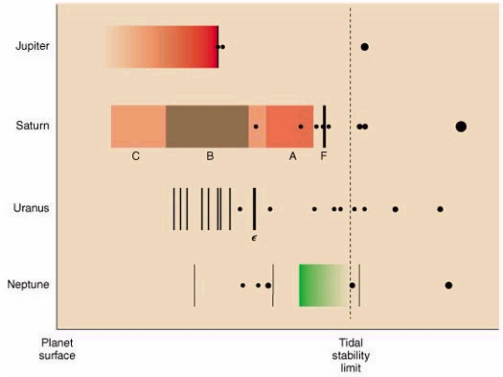
Neptune [Fig 8.29]

4. Why can't the material in the rings collect to form moons?
   a. There is not enough material
   b. The rings are too thin
   c. The rings are inside the Roche limit
   d. The rings are not made of sticky material



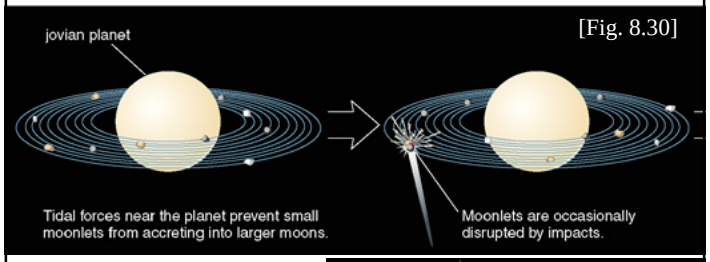
Roche's limit and the Rings

Large objects cannot form in this region,
or get broken up even if they do form.



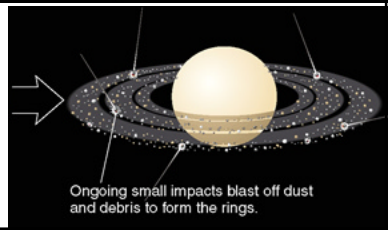
(Roche limit)

Why do the rings still exist?

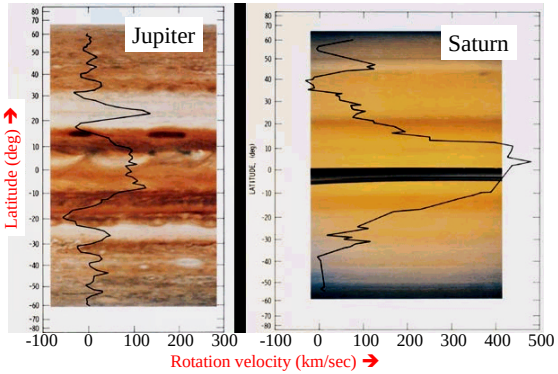


Ring material continually ground down to dust.

➔ must be constantly replenished from moonlets.

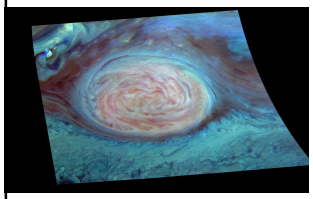


Strong winds, differential rotation



- Different than Earth
  - Fast spin
  - Absence of solid surface underneath.

Jupiter: The Great Red Spot



Color-coded image, showing which light is reflected off which type of clouds. Uses spectroscopy.
Blue = low clouds
Pink = high, thin clouds
White = high, thick clouds

This is a dynamic, evolving storm:
Movie red spot storm

Long-lasting storm, first seen in mid-1600's.

Earth sort of to scale: