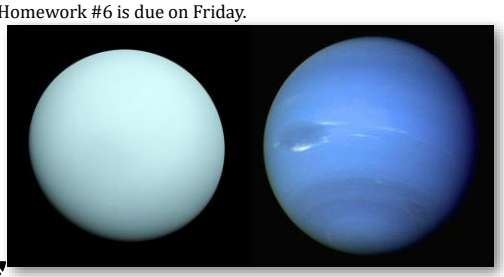
Today's Class: The Ice Giant Planets & their Moons

- Reading on Asteroids - Sections 12.1, 12.2, & 12.5 in Cosmic Perspective.
- Homework #6 is due on Friday.



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Final Paper

- Purpose: *integrate what you have learned about NASA, space astronomy, and space exploration this semester.*
- Choose one of the topics below:
  - Compare and contrast the "space race" between America and the USSR in the 1960s with today's "competition" between the U.S. and Russia and China. What is similar and what is different?
  - Pick a science goal that can be advanced through research on the Moon. Describe why the science is compelling and what infrastructure, using commercial landers and/or Project Artemis, is needed to investigate the science topic.
  - Debate the pros and cons of relying on reusability for rockets, crew vehicles, and landers. As part of your paper, discuss why the Space Shuttle failed to meet its main goal of reducing launch costs using a reusable lifting body. What is different today?
  - What would a "search for life" mission look like on either Mars or Europa (pick one)? Why did you select one and not the other? Describe the kind of spacecraft, sensors, sample collectors, etc. that would be needed to definitively find proof (or not) for life.
  - You are a space entrepreneur. Pick a technology to propose for a space-related start-up company. Build a *basic business plan* for your company including a market strategy and sources of investment. The business plan should include a target market, costs/benefits of the technology, market growth potential, and opportunity for profitability.
- Your grade will be based upon the quality of your research and references, the logic and flow of the paper, integration of the theme of your paper with class topics, and good grammar with complete sentences and paragraphs.
- You are expected to cite at least three external references, NOT including Wikipedia, along with class notes and readings.
- Any text taken verbatim from references MUST be in quotations.
- Maximum length is 5 pages, single-spaced, 12 pt font, 1-inch margins. References are in addition to the five pages of text.

2

When BepiColombo is finished studying properties of Mercury including; volatiles, magnetosphere, elemental composition and mineralogy, will it be concluded that Mercury's formation was a result of a large impact given its large core compared to the low amount of surrounding material.

Presentation by Michael Bennett

- BepiColombo is a co-op mission launched in 2018 consisting of ESA and JAXA.
- The MESSENGER mission by NASA completed in 2015, found proof of volcanism on Mercury and BepiColombo will investigate further when it approaches Mercury in 2025.
- The space probe; Mariner 10 studied Mercury in 1973 and found a magnetic field.
- One satellite will orbit Mercury at about 480 km away from the surface with the purpose of taking images and another at about 11,000 km away from the surface tasked in studying the magnetosphere.

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Last Class

- The Saturn System
  - –Titan
  - –Enceladus
- NASA's Cassini mission

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Class Exercise: Saturn's Rings…

a) Have looked basically the same since they formed along with Saturn.
b) Were created long ago when tidal forces tore apart a large moon.
c) Were accreted from the asteroid belt.
d) Are continually supplied with new particles by impacts from small moons.

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Today's Class

- Overview of Uranus & Neptune.
  - Densities & Interiors of Jovian planets.
  - Atmospheres of Ice Giants compared to Gas Giants.
- The moons of Uranus & Neptune
  - Triton

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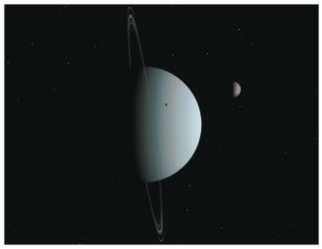
Uranus



- Smaller than Jupiter/Saturn; much larger than Earth
- Made of H/He gas and **hydrogen compounds** (H_2O, NH_3, CH_4)
- Extreme axis tilt
- Moons and rings

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Neptune

- Similar to Uranus (except for axis tilt)
- Many moons (including Triton)

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Jovian Planet Composition

- Jupiter and Saturn
  - Mostly H and He gas
- Uranus and Neptune
  - Mostly hydrogen compounds: water (H_2O), methane (CH_4), ammonia (NH_3)
  - Some H, He, and rock

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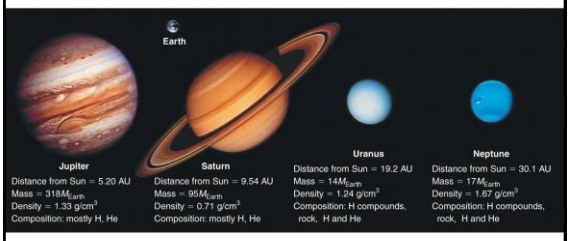
Are Jovian planets all alike?



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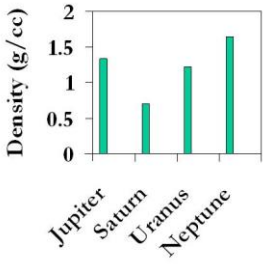
Density Differences



- Uranus and Neptune are denser than Saturn because they have less H/He, proportionately.

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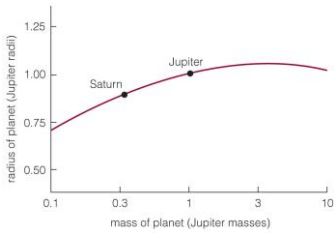
Sizes & Densities of Jovian Planets



- Greater compression is why Jupiter is not much larger (but denser) than Saturn even though it is three times more massive.
- Jovian planets with even more mass can be smaller & denser than Jupiter.

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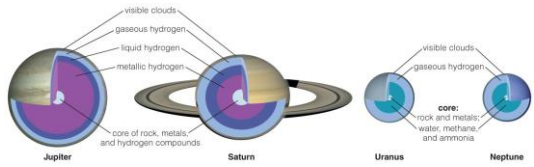
Comparing Jovian Interiors



- Models suggest cores of jovian planets have similar composition.
- Lower pressures inside Uranus and Neptune mean no metallic hydrogen.

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Internal Heat of Outer Planets

- Saturn, like Jupiter, radiates twice as much energy as it receives from the Sun.
- Neptune emits nearly twice as much energy as it receives, but the source of that energy remains mysterious.

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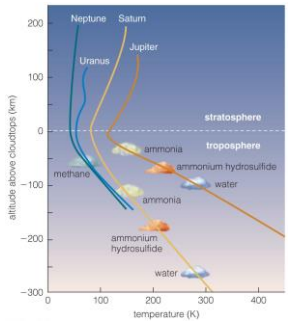
Jovian Planet Atmospheres



- Other jovian planets have cloud layers similar to Jupiter's.
- Different compounds make clouds of different colors.

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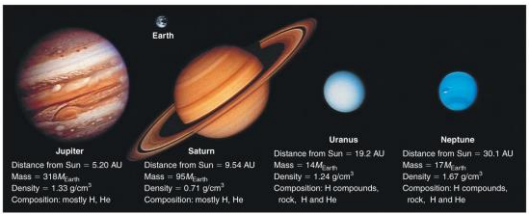
Methane on Uranus and Neptune

- Methane gas of Neptune and Uranus absorbs red light but transmits blue light.
- Blue light reflects off methane clouds, making those planets look blue.



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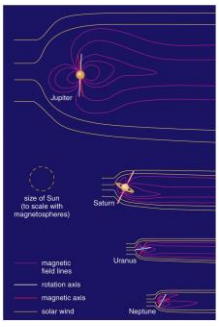
Magnetospheres



- All Jovian planets have substantial magnetospheres, but Jupiter's is the largest by far.

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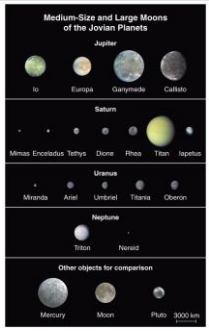
Medium and Large Moons



- Enough self-gravity to be spherical
- Have substantial amounts of ice
- Formed in orbit around Jovian planets
- Circular orbits in same direction as planet rotation

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Small Moons

- These are far more numerous than the medium and large moons.
- They do not have enough gravity to be spherical: Most are "potato-shaped."

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Small Moons

- They are captured asteroids or comets, so their orbits do not follow usual patterns.

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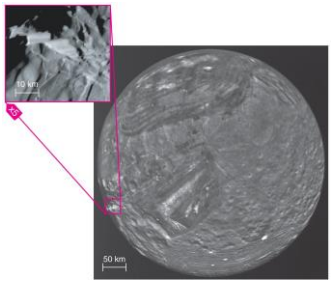
Medium Moons of Uranus



- They have varying amounts of geological activity.
- Miranda has large tectonic features and few craters (possibly indicating an episode of tidal heating in past).

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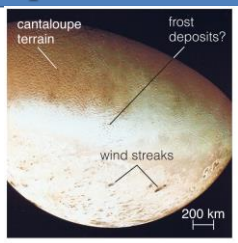
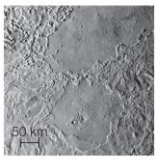
Neptune's Moon Triton



Triton's southern hemisphere as seen by *Voyager 2*.



This close-up shows lava-filled impact basins similar to the lunar maria, but the lava was water or slush rather than molten rock.

- Similar to Pluto, but larger
- Evidence of past geological activity

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What did we learn today?

- Overview of Uranus & Neptune.
  - Densities & Interiors of Jovian planets.
  - Atmospheres of Ice Giants compared to Gas Giants.
- The moons of Uranus & Neptune
  - Triton

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