Chapter 7
Our Planetary System

7.1 Studying the Solar System

Our goals for learning:
• What does the solar system look like?
• What can we learn by comparing the planets to one another?
• What are the major features of the Sun and planets?

What does the solar system look like?

- Eight major planets with nearly circular orbits
- Pluto is smaller than the major planets and has a more elliptical orbit

Thought Question
How does the Earth-Sun distance compare with the Sun’s radius

a) It’s about 10 times larger.
b) It’s about 50 times larger.
c) It’s about 200 times larger.
d) It’s about 1000 times larger.
Thought Question
How does the Earth-Sun distance compare with the Sun’s radius
a) It’s about 10 times larger.
b) It’s about 50 times larger.
c) It’s about 200 times larger.
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What can we learn by comparing the planets to one another?

Comparative Planetology

- We can learn more about a world like our Earth by studying it in context with other worlds in the solar system.
- Stay focused on processes common to multiple worlds instead of individual facts specific to a particular world.

What are the major features of the Sun and planets?

Sun and planets to scale

Planets are very tiny compared to distances between them.
Over 99.9% of solar system’s mass
- Made mostly of H/He gas (plasma)
- Converts 4 million tons of mass into energy each second

Made of metal and rock; large iron core
- Desolate, cratered; long, tall, steep cliffs
- Very hot and very cold: 425°C (day), –170°C (night)

Nearly identical in size to Earth; surface hidden by clouds
- Hellish conditions due to an extreme greenhouse effect:
  - Even hotter than Mercury: 470°C, day and night

An oasis of life
- The only surface liquid water in the solar system
- A surprisingly large moon

Looks almost Earth-like, but don’t go without a spacesuit!
- Giant volcanoes, a huge canyon, polar caps, more…
- Water flowed in distant past; could there have been life?

Much farther from Sun than inner planets
- Mostly H/He; no solid surface
- 300 times more massive than Earth
- Many moons, rings …
Jupiter’s moons can be as interesting as planets themselves, especially Jupiter’s four Galilean moons:

- Io (shown here): Active volcanoes all over
- Europa: Possible subsurface ocean
- Ganymede: Largest moon in solar system
- Callisto: A large, cratered “ice ball”

Rings are NOT solid; they are made of countless small chunks of ice and rock, each orbiting like a tiny moon.

Saturn

- Giant and gaseous like Jupiter
- Spectacular rings
- Many moons, including cloudy Titan

Cassini probe arrived July 2004 (Launched in 1997)

Uranus

- Smaller than Jupiter/Saturn; much larger than Earth
- Made of H/He gas & hydrogen compounds (H₂O, NH₃, CH₄)
- Extreme axis tilt
- Moons & rings

Neptune

- Similar to Uranus (except for axis tilt)
- Many moons (including Triton)
Pluto (and other Dwarf Planets)

- Much smaller than major planets
- Icy, comet-like composition
- Pluto’s main moon (Charon) is of similar size

Thought Question
What process created the elements from which the terrestrial planets were made?

a) The Big Bang
b) Nuclear fusion in stars
c) Chemical processes in interstellar clouds
d) Their origin is unknown

What have we learned?

- What does the solar system look like?
  - Planets orbit Sun in the same direction and in nearly the same plane.
- What can we learn by comparing the planets to one another?
  - Comparative planetology looks for patterns among the planets.
  - Those patterns give us insight into the general processes that govern planets
  - Studying other worlds in this way tells us about our own Earth

Thought Question
What process created the elements from which the terrestrial planets were made?

a) The Big Bang
b) Nuclear fusion in stars
c) Chemical processes in interstellar clouds
d) Their origin is unknown

What have we learned?

- What are the major features of the Sun and planets?
  - Sun: Over 99.9% of the mass
  - Mercury: A hot rock
  - Venus: Same size as Earth but much hotter
  - Earth: Only planet with liquid water on surface
  - Mars: Could have had liquid water in past
  - Jupiter: A gaseous giant
  - Saturn: Gaseous with spectacular rings
  - Uranus: A gas giant with a highly tilted axis
  - Neptune: Similar to Uranus but with normal axis
  - Dwarf Planets: Most (like Pluto) are icy like comets
7.2 Patterns in the Solar System

Our goals for learning:
• What features of our solar system provide clues to how it formed?

Motion of Large Bodies
• All large bodies in the solar system orbit in the same direction and in nearly the same plane
• Most also rotate in that direction

Two Main Planet Types
• Terrestrial planets are rocky, relatively small, and close to the Sun
• Jovian planets are gaseous, larger, and farther from Sun

Swarms of Smaller Bodies
• Many rocky asteroids and icy comets populate the solar system

Notable Exceptions
• Several exceptions to the normal patterns need to be explained
Special Topic:
How did we learn the scale of the solar system?

Transit of Venus

• Apparent position of Venus on Sun during transit depends on distances in solar system and your position on Earth

Transit of Venus: June 8, 2004

Measuring Distance to Venus

• Measure apparent position of Venus on Sun from two locations on Earth
• Use trigonometry to determine Venus’ distance from the distance between the two locations on Earth

What have we learned?

• What features of the solar system provide clues to how it formed?
  – Motions of large bodies: All in same direction and plane
  – Two main planet types: Terrestrial and jovian
  – Swarms of small bodies: Asteroids and comets
  – Notable exceptions: Rotation of Uranus, Earth’s large moon, etc.

7.3 Spacecraft Exploration of the Solar System

Our goals for learning:
• How do robotic spacecraft work?

How do robotic spacecraft work?
Flybys

• A flyby mission flies by a planet just once
• Cheaper than other mission but have less time to gather data

Orbiters

• Go into orbit around another world
• More time to gather data but cannot obtain detailed information about world’s surface

Probes or Landers

• Land on surface of another world
• Explore surface in detail

Sample Return Missions

• Land on surface of another world
• Gather samples
• Spacecraft designed to blast off other world and return to Earth
• Apollo missions to Moon are only sample return missions to date

Combination Spacecraft

• Cassini/Huygens mission contains both an orbiter (Cassini) and a lander (Huygens)

What have we learned?

• How do robotic spacecraft work?
  – Flyby: Flies by another world only once.
  – Orbiter: Goes into orbit around another world
  – Probe/Lander: Lands on surface
  – Sample Return Mission: Returns a sample of another world’s surface to Earth