Jupiter

First of the Gas Giants
Vital Statistics

- Mean Distance from Sun 5.203 AU (7.783 x 10^8 km)
- Mean Orbital Speed 13.1 km/sec
- Sidereal Period 11.86 years
- Rotation Period 9 hrs, 55 min
- Inclination of Axis 3 deg, 4 min
- Inclination of Orbit 1 deg, 18 minutes
- Mass 317.89 M_E (1.90 x 10^{27} kg)
- Mean Density 1.314 g/cm^3
- Albedo 0.51
- Radius 11.2 R_E (~71,500 km)
General Observations

- 11.2 times diameter of Earth
- 317 times as massive as Earth
- 1300 times the volume of Earth

Low Density
- Larger than that of water
- but less than that of rock

Composition is nearer to that of the Sun

Composition probably still the same as when it formed

63 moons

Jupiter Rotation Movie
Atmospheric Structure

Contains two prime regions
Stratosphere
Troposphere
Where the weather occurs

The bright colored clouds are different cloud layers at different depths

The ordering of the colors as one moves inwards and thus to higher temperatures is

Red, White, Brown, then Blue
Atmospheric Composition

• Primarily made up from two gases
  – By Fraction of gas molecules Mass
  – Hydrogen 86% 75%
  – Helium 13% 24%
  – Atmospheric composition of Hydrogen and Helium close to theoretical composition primordial solar nebula

• Methane and Ammonia also seen are in the atmosphere

• Ices of ammonia, water, and ammonium hydrosulfide are also seen

• White and blue colors in the atmosphere are due to \( \text{CO}_2 \) and \( \text{H}_2\text{O} \)
Jupiter’s Structure

Thought to consist of a dense small rocky core
Core mass 12 to 45 times that of Earth’s total mass

Core region surrounded by metallic hydrogen
Crystal lattice of protons with electrons free to move
Extends outward to ~ 78% of radius

Next is a transparent layer of liquid and gaseous hydrogen
Temperature at core boundary estimated to be 36,000 K
Weather Systems

• **High Pressure System**
  • Excess amount of air, Greater downward pressure
• **Low Pressure System**
  • Lesser amount of air, Lower downward pressure
• Air in High Pressure System should flow directly towards Low Pressure System
• Rotation of planet complicates things - Coriolis Effect
  • Winds are deflected from straight line motion
  • Winds move clockwise or counterclockwise
Coriolis Effect
Weather Rotation Patterns

• Northern Hemisphere:
  – High Pressure  Clockwise
  – Low Pressure  Counterclockwise

• Southern Hemisphere:
  – High Pressure  Counterclockwise
  – Low Pressure  Clockwise
Jupiter's Prominent Features

Alternating bands of dark and light

• Dark Bands --- Belts
  – Belts are descending cooler gases

• Light Bands --- Zones
  – Zones are ascending warmer gases
Jupiter's Prominent Features

The belts and zones are counter rotating and where they meet they cause eddies and currents.

Winds speeds can exceed 350 km/hr.
The Winds of Jupiter

Real picture is much more complicated

Wind speed with respect to internal rotation rate
The Winds of Jupiter

- Measurements by the Galileo probe show high wind speeds even at great depth

- Probably due to heating from planet, not from Sun
Great Red Spot

• First noticed by Galileo
• At least 350 years old
• Its size is ~ 40,000 km by 14,000 km
  – Three Earths could fit into it
• At boundary between belt and zone
• Since the Great Red Spot is
  • In the southern hemisphere of Jupiter
  • Rotates counterclockwise with a period of about 6 days
  ➢ It is a High Pressure System
Mathematical models suggest this system is stable
Spot is not associated with any deep feature on planet’s surface

Gets its energy from
Counter rotating belts and zones, and
Heat from lower warmer atmosphere

Red Spot Rotation
YouTube Video1
YouTube Video2
Other Storm Systems

There also exist white and brown oval storms

White ovals – relatively cool clouds within upper atmosphere
Brown ovals – warmer and within “normal cloud layer”

White ovals are confined to circular belts
Jupiter’s Rotation

- Jupiter rotates differentially
  - The rate at which Jupiter rotates at the equator is not the same as at the polar regions
- At the equator
  - 9 hours, 50 minutes, 30 seconds
- At the poles
  - 9 hours, 55 minutes, 41 seconds
Jupiter’s Rotation

Jupiter is NOT a rigid body

It is rotating very rapidly

Jupiter is oblate - slightly flattened

Equatorial diameter is 6% larger than polar diameter

High rotation rate + fluid planetary structure = oblateness

The smaller the core of a Jovian world, the more oblate its shape
Jupiter’s Radiation

Jupiter emits more radiation than it receives from the Sun.
Extra energy is due to gravitational potential energy release.
Radiation emitted is consistent with a thermal blackbody.

Other radiation observed:
- Bursts of radiation at 10 meter wavelength
  - Discharges in the Ionosphere of Jupiter
  - Associated with the moon Io
- Synchrotron Radiation in the 3 - 75 cm wavelengths
  - Electrons interacting with the strong magnetic field of Jupiter
Jupiter's Magnetic Field

- Very strong magnetic field
  - Intrinsic field strength is **20,000 times that of Earth**
- Small core cannot produce such a strong field
- Pressure deep inside dissociates the hydrogen into electrons and protons producing a liquid sea
- Electrons move as if in a metal
  - **Liquid Metallic Hydrogen**
- Occurs at depths of 20,000 - 25,000 Km below the cloud tops
- Pressure approximately 3 million atmospheres.
- Region is about 32,000 - 40,000 km thick
Jupiter's Magnetic Field

Jupiter is surrounded by belts of charged particles, much like the Van Allen belts but vastly larger.

Magnetosphere is 30 million km across
Aurorae

Just as Earth, Jupiter’s magnetic field traps particles and these particles interact with the atmosphere causing aurorae.

Many of the particles that are trapped originated from the moon Io.
Jupiter’s Ring

Jupiter has been found to have a small, thin ring
Comet Shoemaker-Levy 9

21 comet fragments hit Jupiter between July 16, 1994 and July 22, 1994

Some fragments created large fireballs that rose above the limb of Jupiter and left giant dark marks on the planet

Fireballs are bubbles of hot gases being a mixture of Jovian atmosphere and cometary material
Comet Shoemaker-Levy 9

Later pictures showed dark semicircles – *ejecta blankets*

Made from material either from comet or Jupiter itself

Suspended in the upper atmosphere

[Shoemaker-Levy Impact Video 1](#)
'HAVING A GAS! - HERE AT

JUPITER
THE GIANT PLANET

Callisto
- The Most Cratered Moon
Methane Hurricanes

Cute Little Red
Spot

Giant Red Spot

Volcanic Moon

The Great Red Spot
Belts and Zones

Size of Earth

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