

CHAPTER 07: THE JOVIAN PLANETS

NOTES AND SKETCHES

7.1: OBSERVATIONS OF JUPITER AND SATURN

The View From Earth

- ◆ Jupiter and Saturn are naked-eye objects
- ◆ Uranus and Neptune can be seen using telescopes

Spacecraft Exploration**Pioneers**

- ◆ Pioneer 10: Launch Mar 72, Jupiter flyby Dec 73 (data relayed through Apr 02)
- ◆ Pioneer 11: Launch Apr 73, Jupiter Dec 74, Saturn Sep 79 (daily operation stopped Sep 95)

Voyager I

- ◆ Launched Sep 77
- ◆ Jupiter flyby Mar 79
- ◆ Saturn flyby Nov 80
- ◆ Family Portrait Feb 90
- ◆ Still transmitting!!!

Voyager II

- ◆ Launched Aug 77
- ◆ Jupiter: Jul 79
- ◆ Saturn: Aug 81
- ◆ Uranus: Jan 86
- ◆ Neptune: Aug 89

Galileo

- ◆ Launched Oct 89
- ◆ Reached Jupiter Dec 95
- ◆ Orbit until Sep 03
- ◆ Decommissioned by sending it crashing into Jupiter

Cassini-Huygens

- ◆ Launched Oct 97
- ◆ Jupiter flyby Dec 00
- ◆ Arrived at Saturn Jul 04
- ◆ Huygens probe separates for Titan: Jan 05
- ◆ Still operational

New Horizons

- ◆ Launched Jan 06
- ◆ Jupiter flyby Feb 07
- ◆ Headed for Pluto then Kuiper belt

7.2: DISCOVERIES OF URANUS AND NEPTUNE

- ◆ Uranus: 1781, William & Caroline Herschel use telescope
- ◆ Neptune: 1846, Adams & Leverrier (independently) use gravity

7.3: BULK PROPERTIES OF THE JOVIAN PLANETS

Physical Characteristics

- ◆ All jovians are much less dense than terrestrials
- ◆ Saturn is least dense; less dense than water
- ◆ No solid surface; gaseous atmosphere gets hotter & denser deeper below surface until it becomes liquid
- ◆ Solid core larger than Earth (not Fe-Ni, probably rocky)

Rotation Rates

- ◆ All are spinning faster than the Earth
- ◆ Differential rotation: Rotation at poles is slower than rotation at equator
- ◆ Fluid dynamics: differential rotation is result of complicated system of energy transfer

Uranus' Retrograde Rotation

- ◆ Axial tilt is 98°
- ◆ Uranus is literally spinning on its side
- ◆ Probable result of glancing collision (similar to Venus), but there is no way to prove this

7.4: JUPITER'S ATMOSPHERE**NOTES AND SKETCHES****Overall Appearance and Composition**

- ◆ Mostly hydrogen (86%)
- ◆ What's not hydrogen is mostly helium (bit less than 14%)
- ◆ Color comes from tiny amounts of complex chemistry
- ◆ Reddish, yellow, orange, brownish colors from sulfur compounds

Zones and Belts

- ◆ Light white/cream/yellow bands = zones (high pressure)
- ◆ Darker orange/red/brown bands = belts (low pressure)
- ◆ Convection bands: Hot zones rise, cool belts fall
- ◆ This is more of that energy transfer/fluid dynamics
- ◆ Zonal flow: Stable east-west winds found below cloud bands

Atmospheric Structure

- ◆ Layered structure: Separate cloud decks with different compositions
- ◆ Pressure increases with increasing depth
- ◆ Temperature increases with increasing depth

Weather on Jupiter

- ◆ Great Red Spot = age unknown; has existed since first telescopic observations
- ◆ Complex storm systems: Energy from interior
- ◆ Other ovals, spots: Smaller systems have shorter duration

7.5 THE ATMOSPHERES OF THE OUTER JOVIAN WORLDS**Composition of Saturn's Atmosphere**

- ◆ About 92.4% hydrogen, 7.4% helium (missing helium?)
- ◆ Similar to Jupiter, but everything is less dramatic
- ◆ Similar pattern of zones, belts, ovals
- ◆ Cloud decks: Similar to Jupiter, but less compressed (less gravity), about 3 times thicker
- ◆ Thicker top layer clouds = more uniform appearance

Weather on Saturn

- ◆ Great White Spot = transient storm (detected in 1990, approximately 2 month lifecycle)
- ◆ Dragon Storm = observed in 2006, but probably a long-term effect (energy from interior)

Atmospheric Conditions of Uranus and Neptune

- ◆ Mostly hydrogen (84%), slightly less than Jupiter & Saturn
- ◆ Helium about 14% (very close to J & S)
- ◆ Major difference is the methane (CH_4): Uranus \approx 2%, Neptune \approx 3%
- ◆ Methane causes blue color (absorbs longer wavelength red/green light)

Weather on Uranus and Neptune

- ◆ Farther = colder: Less solar heating to drive any weather
- ◆ Weather relies on internal energy: Smaller planets, less internal heat
- ◆ Neptune: Great Dark Spot = transient storm spot

7.6: JOVIAN INTERIORS**Internal Structure**

- ◆ Low density means no heavy metallic core (some metal, just not much as compared to terrestrials)
- ◆ Cores are still much larger than Earth!
- ◆ J & S layered structure = rocky/icy core, metallic hydrogen, molecular hydrogen
- ◆ U & N layered structure = rocky core, water/ammonia slush, molecular hydrogen
- ◆ U & N: Not big enough to metallize hydrogen (insufficient temperature & pressure)

NOTES AND SKETCHES

Magnetospheres

- ◆ J & S: Strong magnetic fields dynamically generated by rotation of metallic hydrogen
- ◆ Jupiter: Magnetic axis aligned with rotation axis
- ◆ Saturn: Magnetic axis 10° off rotation axis, still mostly aligned (very similar to Earth)
- ◆ U & N: Significant field strength, probably due to electrical conduction through ammonia-water slush
- ◆ U & N: Magnetic axis not aligned *at all* with rotation axis

Internal Heating

- ◆ Uranus seems to be the only jovian without an internal heat source
- ◆ Jupiter: Heat of formation (radiates about 2x what it gets from sun)
- ◆ Saturn: Radiates 3x the energy it receives from the sun
- ◆ Helium precipitation on Saturn: He sinks through lighter hydrogen atmosphere, gets compressed by gravitational pressure, releases energy
- ◆ Neptune: Probably heat of formation (CH_4 helps keep heat trapped)