

Planets, Moons, and Rings Overview

Planets

Terrestrial

- Smaller bodies made mostly of rock and metal
- Composition dominated by Si and O
- Atmosphere $< 1/1000^{\text{th}}$ mass of planet
- Natural satellites and dwarf planets are all terrestrial
- Planets
 - Mercury
 - Venus
 - Earth
 - Mars
- Dwarf Planets
 - Ceres
 - Pluto
 - Haumea
 - Makemake
 - Eris
- Exoplanets
 - Super-Earths
 - Mini-Earths

Jovian

- Giant Planets
- Composition dominated by H, He, C, N, O
- Massive balls of gas with ice/rock/metal cores
- Atmospheres comparable to mass of planet
- Gas Giants
 - Jupiter
 - Saturn
 - Hot Jupiters (Exo)
 - Cold Giants (Exo)
- Ice Giants
 - Uranus
 - Neptune
 - Mini-Neptunes (Exo)

Star and Planet Formation

Raw Materials Abundance: Most to Less

- H
- He
- O
- C
- N, Ne
- Mg, Si, Fe
- S, Ar

Protostellar Nebula

- Gas Density
 - $100 - 1000 \text{ cm}^{-3}$
 - Cores $10^3 - 10^6 \text{ cm}^{-3}$
- Starting to collapse under own gravity

Contraction

- 100,000 years
- Gas drag damps oscillations about mid-plane

Condensation

- Critical moment for planetary composition

- Coagulation to 1m sized particle in 1 Myr

Accretion

- Orderly: 100km in 1Myr
- Runaway: gravitational focusing forms embryos/protoplanets $0.1-10 M_{\text{Earth}}$
- Oligarchic: a few rules dominate their feeding zones
- Critical size to accrete non-condensables (H,He): $10 M_{\text{Earth}}$

Clearing

- Jovian planets tug on smaller bodies
- Migration
- Late Heavy Bombardment

Frost-Line

- Within the frost line, rocks and metals condense while H compounds stay gaseous
- Beyond, H compounds, rock, and metals condense
- H and He themselves don't condense anywhere