

## Chapter 10. Outer Worlds

### Uranus and Neptune

- Voyager pictures of Uranus in visible wavelengths show a smooth surface, with hardly any signs of atmospheric activity. However, when the Hubble Space Telescope watched Uranus in infrared, bands of clouds and many moons were detected.
- Voyager pictures of Neptune show bands of clouds and the Great Dark Spot, similar to Jupiter but not as violent. The Great Dark Spot is not a permanent feature; it disappears sometimes.
- Both Uranus and Neptune have ring systems. Uranus has no Galilean satellites, while Neptune has one, Triton.
- Galilean satellites include Io, Europa, Ganymede, and Callisto around Jupiter, the Moon around the Earth, Titan around Saturn, and Triton around Neptune. The Galilean satellites have radii  $>1000$  km.

### Odd Things in the Outer Worlds

- Uranus spins with an inclination angle of  $98^\circ$ , and Pluto  $122^\circ$ . These spin axes are close to the ecliptic plane, while the other planets all have spin axis inclined  $<30^\circ$  from the ecliptic pole.
- Uranus and Neptune have their magnetic fields' origins displaced from their centers.
- Neptune's moon Triton revolves backwards.
- Pluto and Triton are planetesimals.

### Pluto Is the Oddest of All

- Pluto, the outermost planet, is the oddest of all. It is smaller than a Galilean satellite. Its orbit has a large angle with respect to the ecliptic plane. Pluto's moon, Charon, is almost 1/10 as massive as the planet itself. Pluto and Charon were formed in a collision, much like the formation of the Earth and its Moon.

### Comparison between terrestrial and Jovian Planets

|                   | Terrestrial Planets               | Jovian Planets                   |
|-------------------|-----------------------------------|----------------------------------|
| Members           | Mercury, Venus, Earth, Mars       | Jupiter, Saturn, Uranus, Neptune |
| Radius            | $\leq$ Earth                      | $>$ Earth                        |
| Mass              | $\leq$ Earth                      | $\gg$ Earth                      |
| Mean Density      | $\sim 5$ g/cm <sup>3</sup>        | $\sim 1$ g/cm <sup>3</sup>       |
| Satellites        | few                               | many                             |
| Rings             | no                                | yes                              |
| Dominant Elements | heavy elements (Fe, C, O, N, ...) | light elements (H, He, ...)      |
| Surface           | hard surface (solid)              | soft surface (gas, liquid)       |