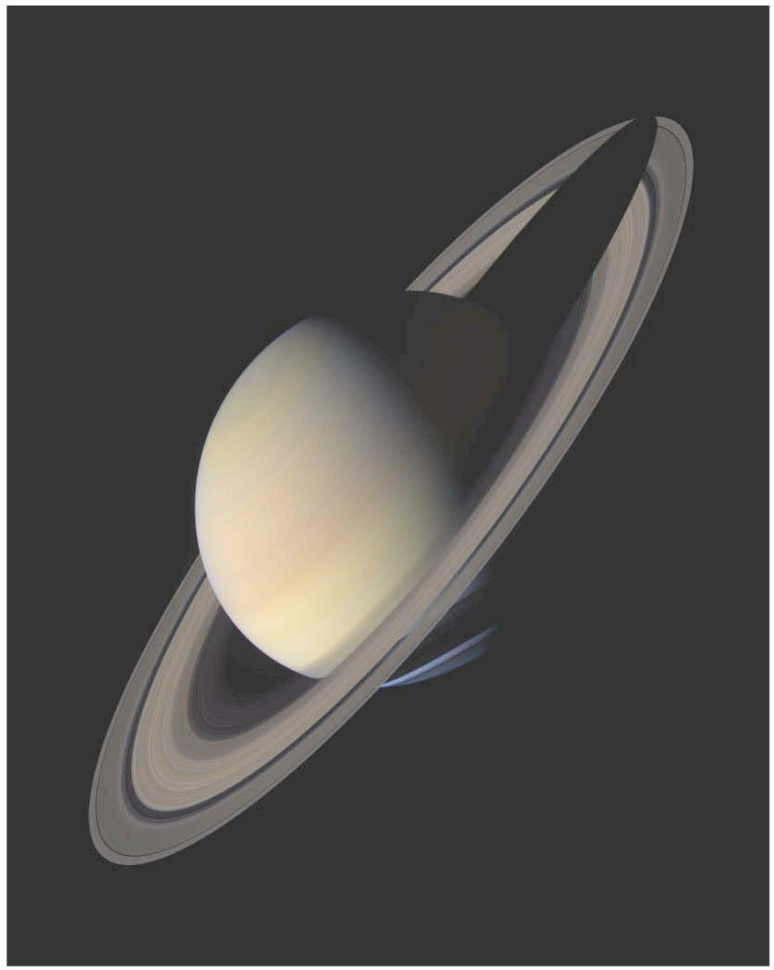
Chapter 6
The Solar System



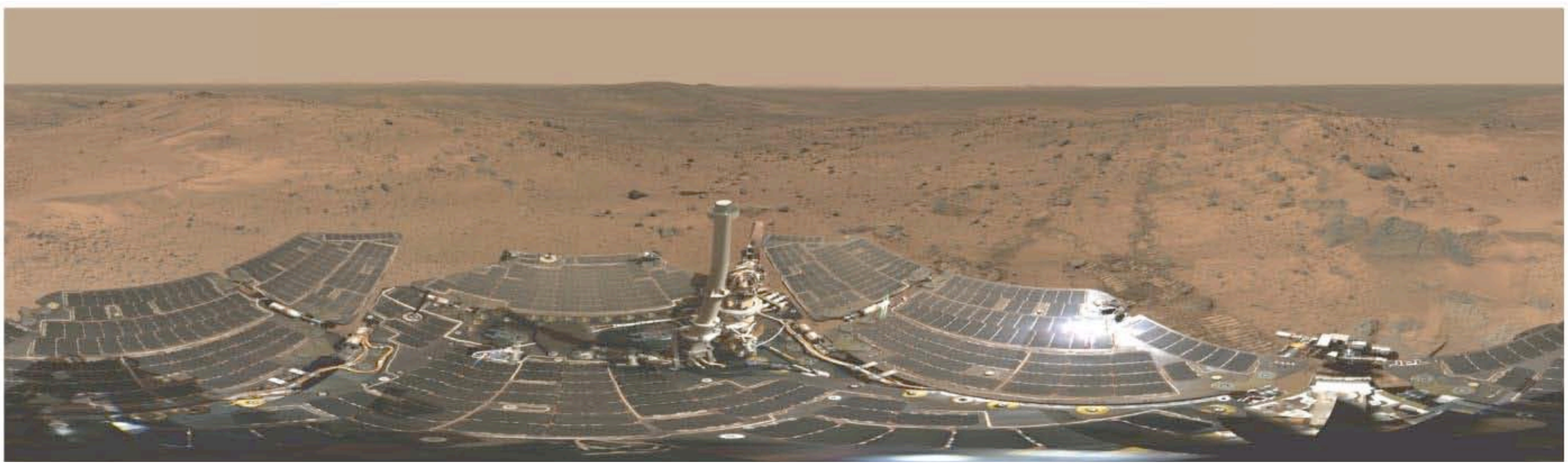
Units of Chapter 6

6.1 An Inventory of the Solar System

Early astronomers knew:

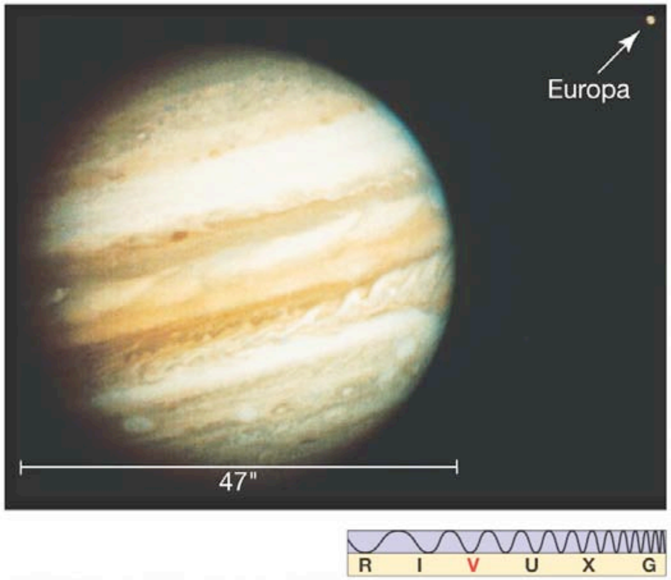
Moon, stars, Mercury, Venus, Mars, Jupiter, Saturn, comets, and meteors

Now known: Solar system has 165 **moons**, one **star**, eight **planets** (added Uranus and Neptune), eight **asteroids** and more than 100 **Kuiper belt objects** more than 300 km in diameter, smaller asteroids, **comets**, and **meteoroids**



6.2 Measuring the Planets

- **Orbital period** can be observed
- **Distance from Sun** using Kepler's laws (which one?)
- **Radius (or diameter)** known from angular size x distance
- **Masses** from Newton's laws. Distance and orbital speed of a planet's moon gives $M = r\,v^2/2G$ ($GMm/r^2 = (1/2)mv^2$).
- **Rotation period** from observations
- **Density** can be calculated knowing radius and mass; density = mass/volume, volume ~ radius^3



Inspect, don't memorize, this table in textbook

TABLE 6.1 Properties of Some Solar System Objects

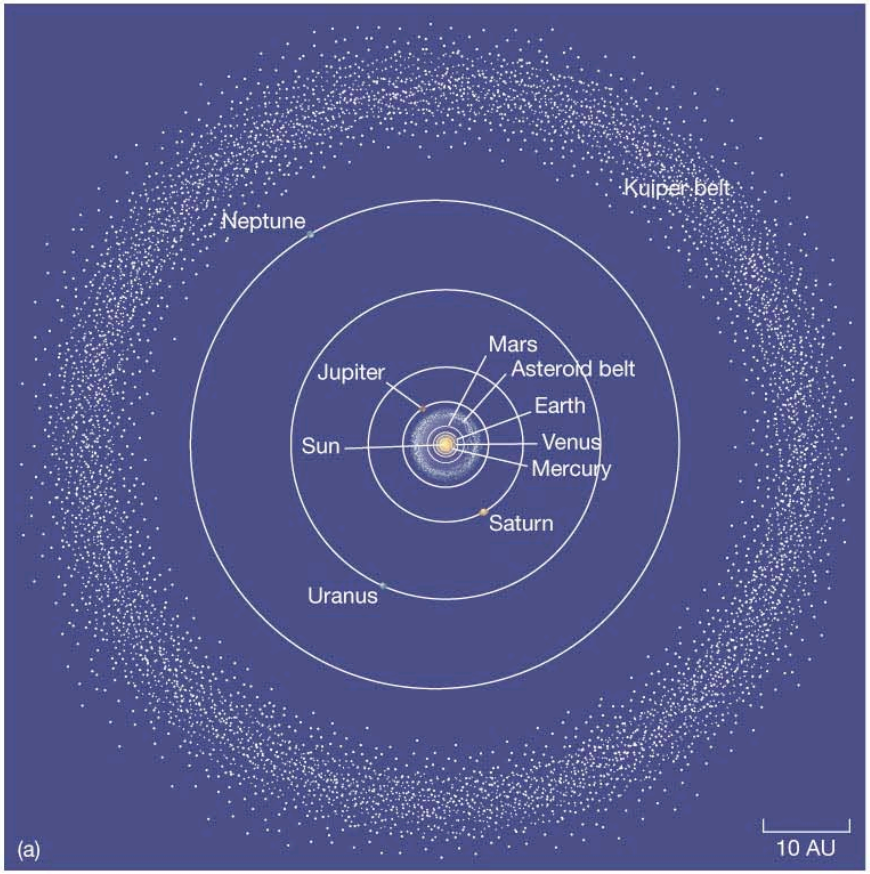
Object	Orbital Semimajor Axis (AU)	Orbital Period (Earth Years)	Mass (Earth Masses)	Radius (Earth Radii)	Number of Known Satellites	Rotation Period * (days)	Average Density (kg/m^3)	Average Density (g/cm^3)
Mercury	0.39	0.24	0.055	0.38	0	59	5400	5.4
Venus	0.72	0.62	0.82	0.95	0	–243	5200	5.2
Earth	1.0	1.0	1.0	1.0	1	1.0	5500	5.5
Moon	—	—	0.012	0.27	—	27.3	3300	3.3
Mars	1.52	1.9	0.11	0.53	2	1.0	3900	3.9
Ceres (asteroid)	2.8	4.7	0.00015	0.073	0	0.38	2700	2.7
Jupiter	5.2	11.9	318	11.2	63	0.41	1300	1.3
Saturn	9.5	29.4	95	9.5	56	0.44	700	0.7
Uranus	19.2	84	15	4.0	27	–0.72	1300	1.3
Neptune	30.1	164	17	3.9	13	0.67	1600	1.6
Pluto (Kuiper belt object)	39.5	248	0.002	0.2	3	–6.4	2100	2.1
Hale–Bopp (comet)	180	2400	1.0×10^{-9}	0.004	—	0.47	100	0.1
Sun	—	—	332,000	109	—	25.8	1400	1.4

**A negative rotation period indicates retrograde (backward) rotation relative to the sense in which all planets orbit the Sun.*

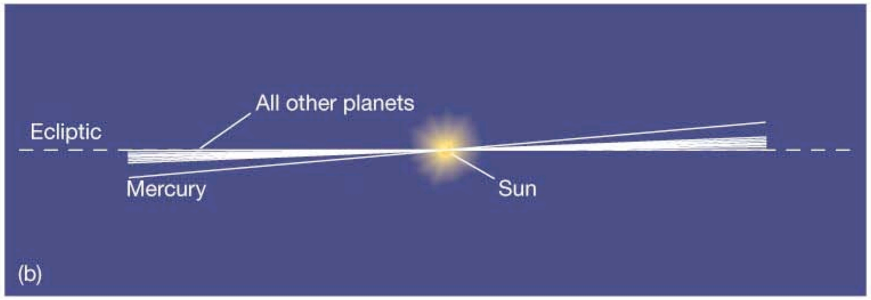
6.3 The Overall Layout of the Solar System

All planetary orbits are elliptical (of course), but very nearly circular.

All planets orbit Sun in same sense, and all but one rotate in that same direction.



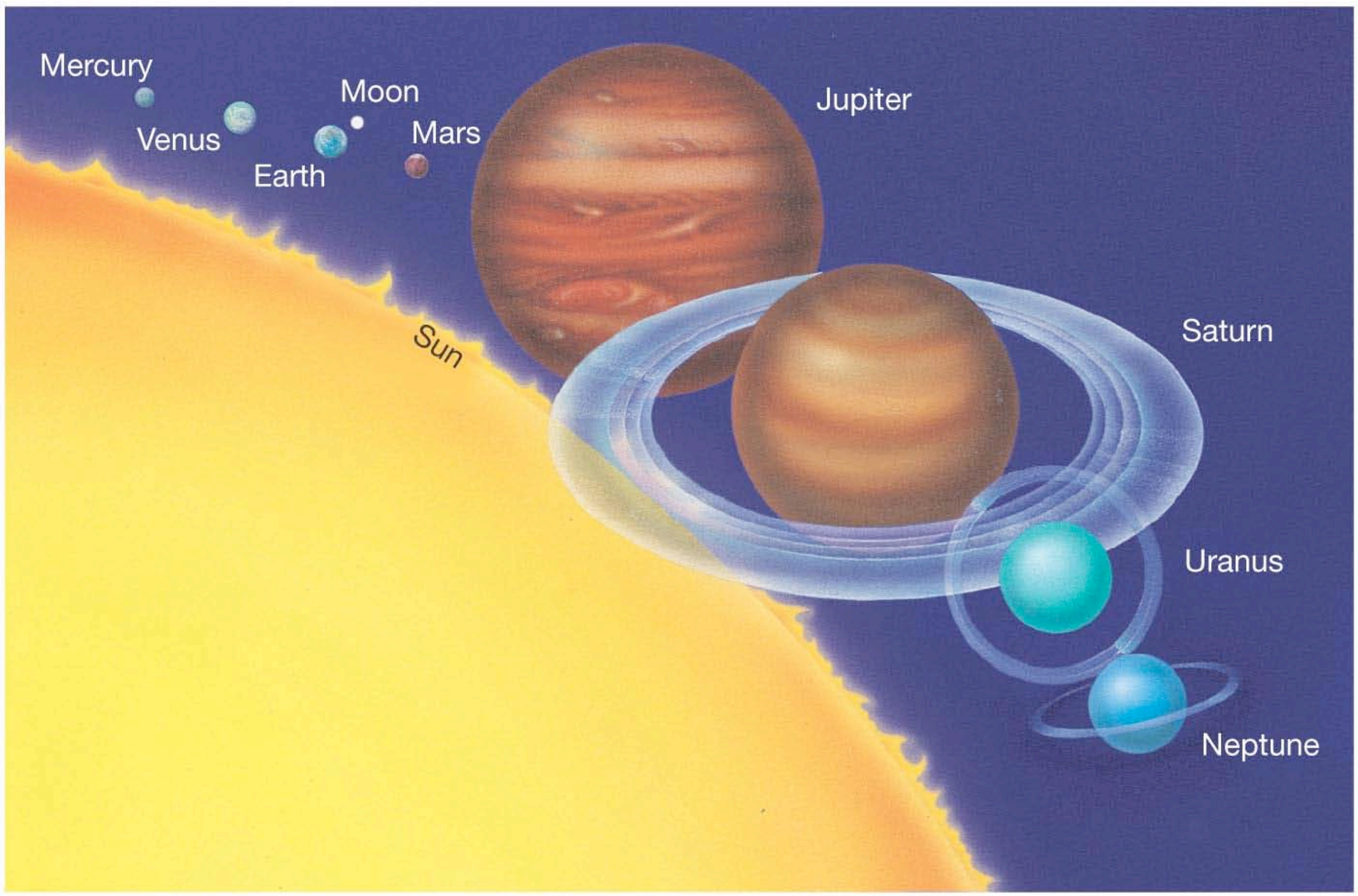
All orbits but Mercury's are close to same plane.



These both suggest that the solar system was originally a rotating disk.

6.4 Terrestrial and Jovian Planets

In this picture of the eight planets and the Sun, many of the differences between the four terrestrial and four jovian planets are clear



6.4 Terrestrial and Jovian Planets

Terrestrial planets:

Mercury, Venus, Earth, Mars

Jovian planets:

Jupiter, Saturn, Uranus, Neptune

The table to right shows differences between the terrestrial and jovian planets. You *should* partially memorize this one!

TABLE 6.2 Comparison of the Terrestrial and Jovian Planets

Terrestrial Planets	Jovian Planets
close to the Sun	far from the Sun
closely spaced orbits	widely spaced orbits
→ small masses	large masses
small radii	large radii
→ predominantly rocky	predominantly gaseous
→ solid surface	no solid surface
→ high density	low density
slower rotation	faster rotation
weak magnetic fields	strong magnetic fields
few moons	many moons
no rings	many rings

6.4 Terrestrial and Jovian Planets

Differences among the terrestrial planets:

• All have atmospheres, but they are very different; surface conditions vary as well. Only Venus and Earth have *thick* atmospheres.

• Temperatures decrease with increasing distance from Sun, as expected, but Venus and Earth have *very* different temperatures!

• Only Earth has liquid water on its surface. Water is a unique liquid and is believed necessary for life (good reasons for thinking this)

• Only Earth has oxygen in its atmosphere: a "biosignature" produced by early cyanobacteria, and a possible way to detect extraterrestrial life.

• Earth and Mars spin at about the same rate; Mercury is much slower, Venus is slow and retrograde (backwards).

• Only Earth and Mars have moons; only Earth has a *huge* moon that is a significant fraction of it's planet's size.

• Only Earth and Mercury have magnetic fields. This is a sign of a rotating core of conducting material (mostly iron).

6.5 Interplanetary Matter

Asteroids and meteoroids have rocky composition; asteroids are bigger

Asteroid **Eros** is 34 km long

(a)

Comets are icy, with some rocky parts

Comet **Hale-Bopp**:

(b)

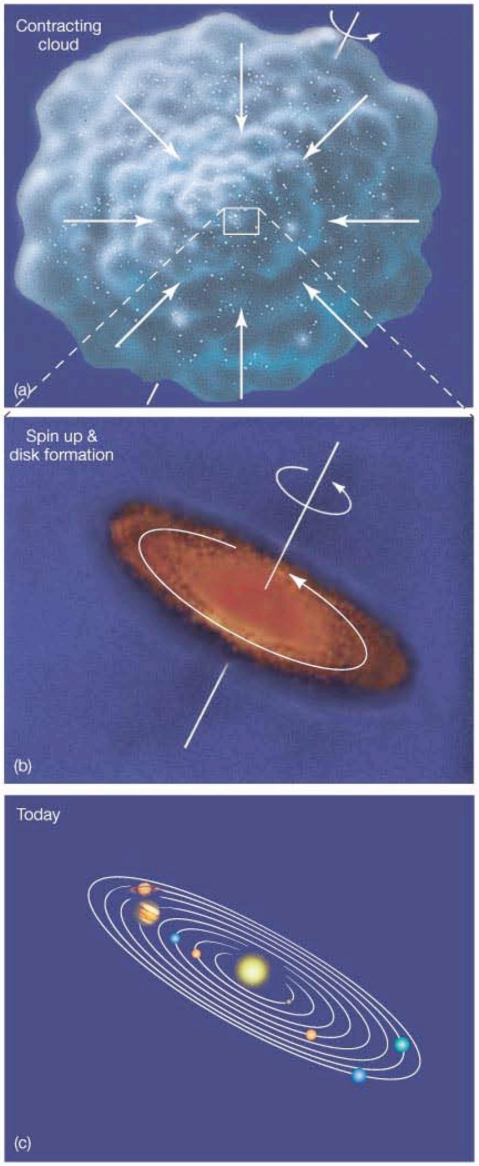
Pluto, once classified as one of the major planets, is the closest large *Kuiper Belt object* to the Sun

6.7 How Did the Solar System Form?

Cloud of gas and dust contracts due to gravity; *conservation of angular momentum* means it spins faster and faster as it contracts.

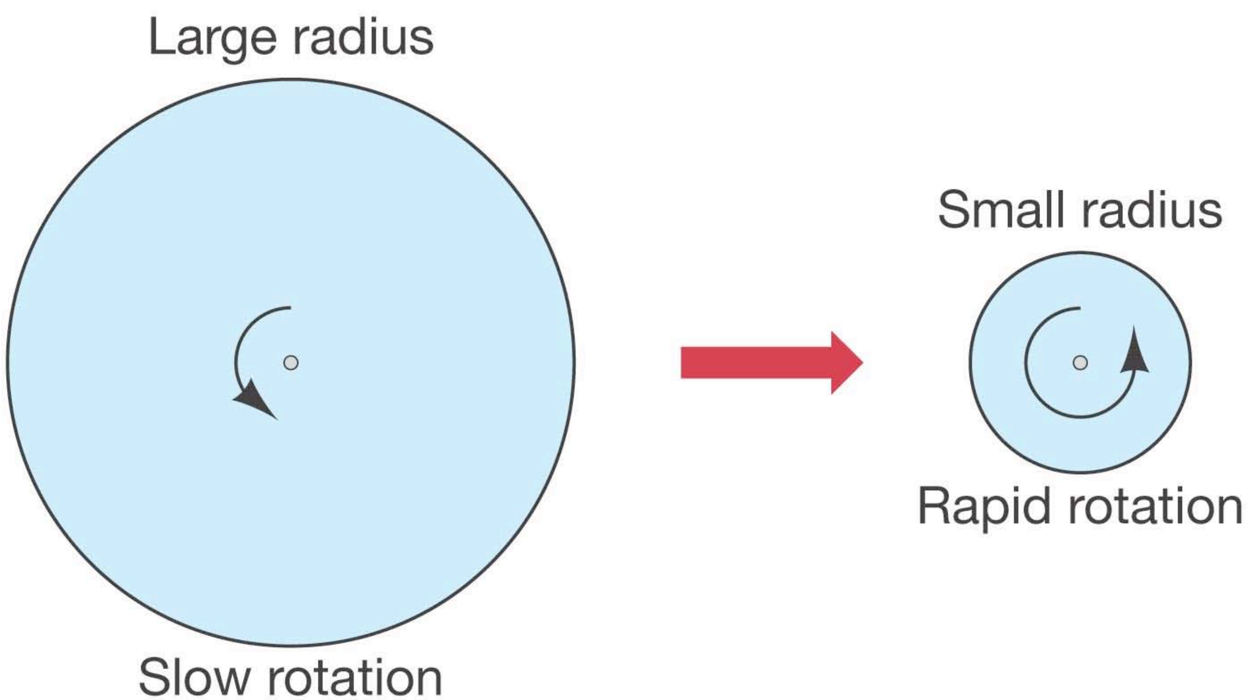
Spin results in a *disk*.

Then, *somehow*, the gas and dust in this disk condensed or agglomerated into planets and the other objects in the solar system.



More Precisely 6-2: Angular Momentum

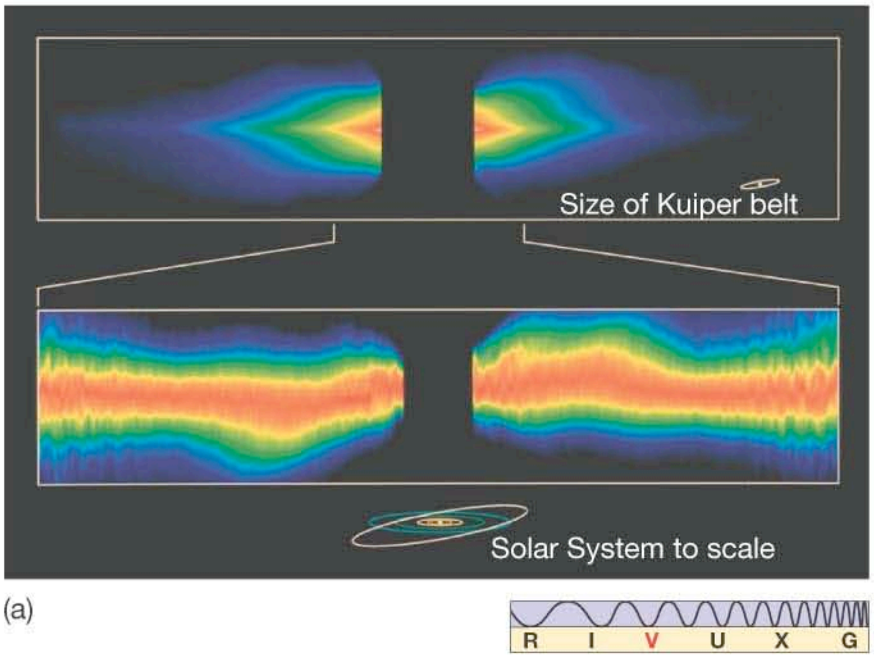
Conservation of angular momentum says that product of radius and rotation rate must be constant



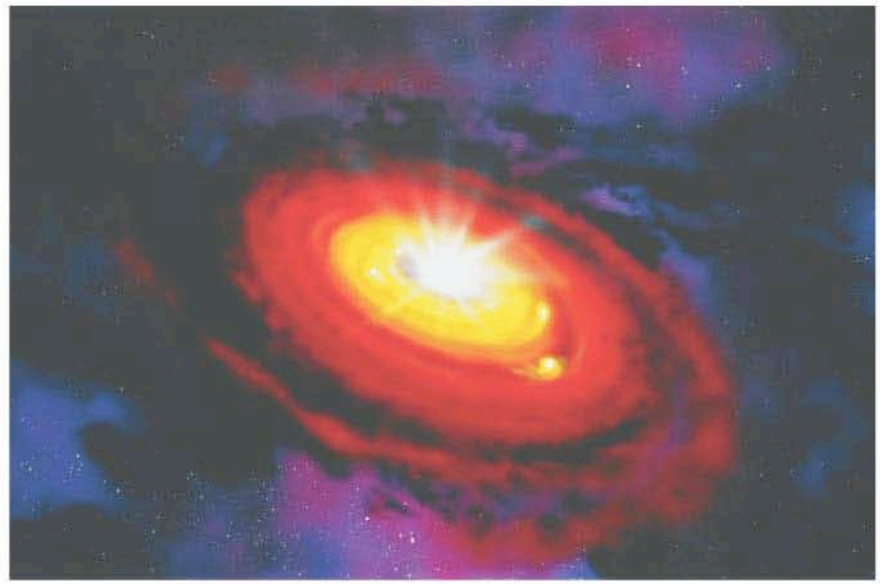
6.7 How Did the Solar System Form?

The observation of disks surrounding newly formed stars supports this theory.

That disks are found around nearly *all* young stars suggests that planetary systems may be common.



(a)



(b)

Summary of Chapter 6

- Solar system consists of Sun and everything orbiting it
- Asteroids are rocky, and most orbit between orbits of Mars and Jupiter
- Comets are icy and are believed to have formed early in the solar system’s life
- Major planets orbit Sun in same sense, and all but Venus rotate in that sense as well
- Planetary orbits lie almost in the same plane

Summary of Chapter 6 (cont.)

- Four inner planets—terrestrial planets—are rocky, small, and dense
- Four outer planets—jovian planets—are gaseous and large
- Nebular theory of solar system formation: cloud of gas and dust gradually collapsed under its own gravity, spinning faster as it shrank
- Condensation theory says dust grains acted as condensation nuclei, beginning formation of larger objects