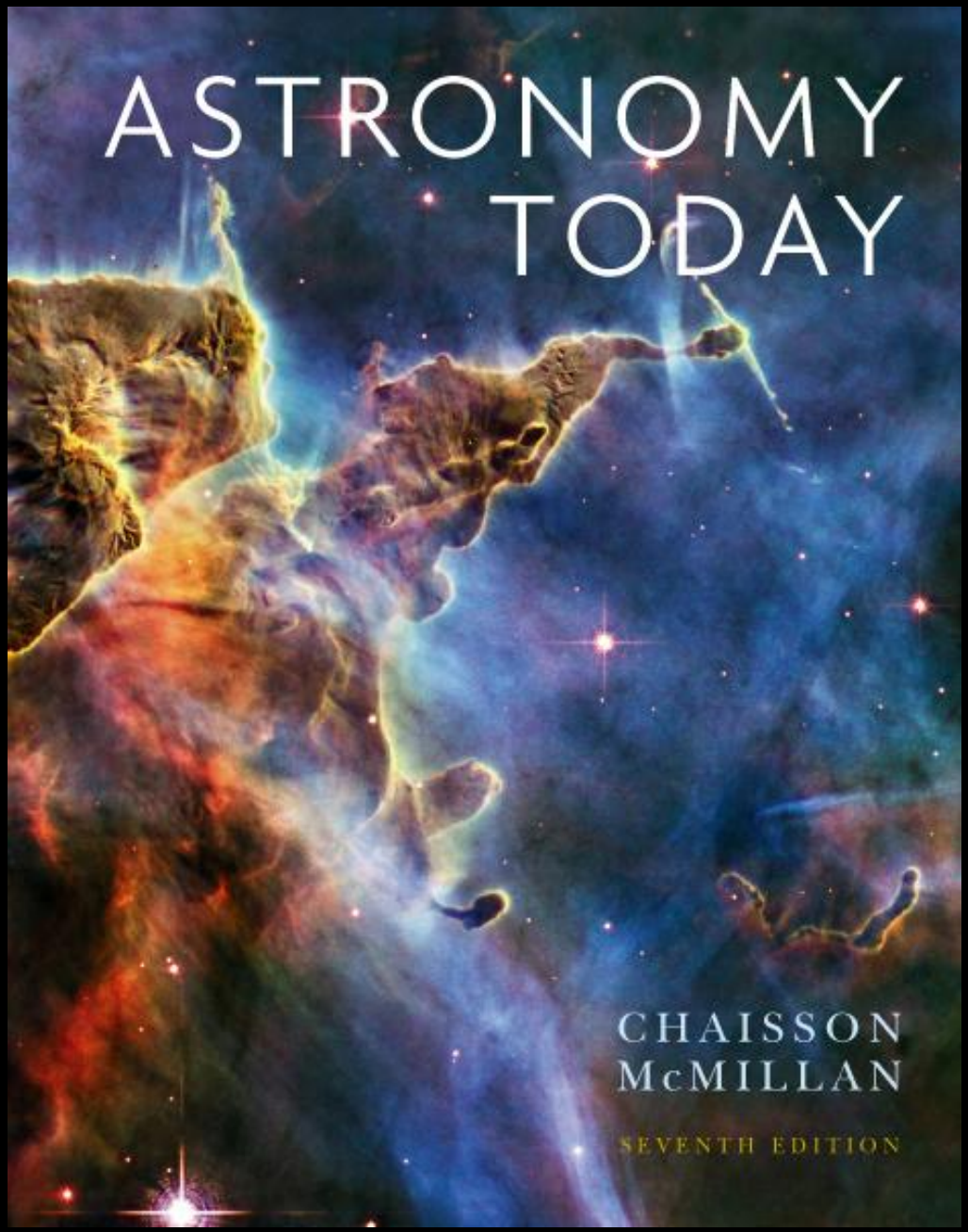


Lecture Outlines

Chapter 6

Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 6
The Solar System

Units of Chapter 6

Units of Chapter 6 (cont.)

6.6 Spacecraft Exploration of the Solar System

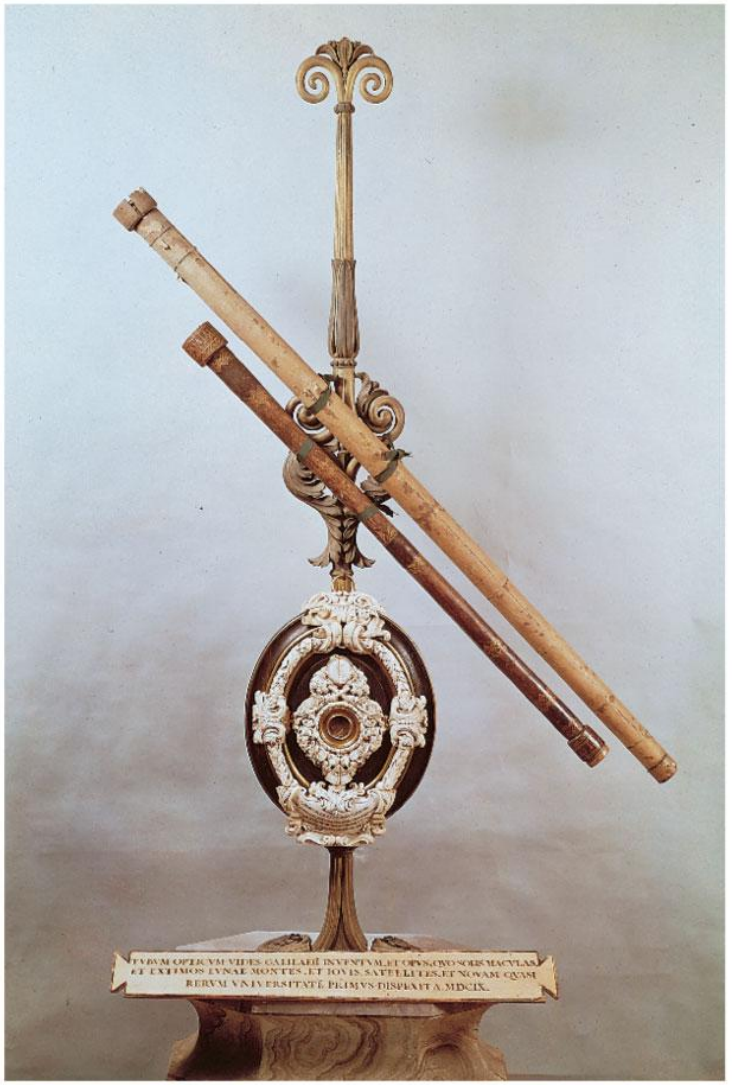
Gravitational "Slingshots"

6.7 How Did the Solar System Form?

Angular Momentum

6.1 An Inventory of the Solar System

Early astronomers knew Moon, stars, Mercury, Venus, Mars, Jupiter, Saturn, comets, and meteors



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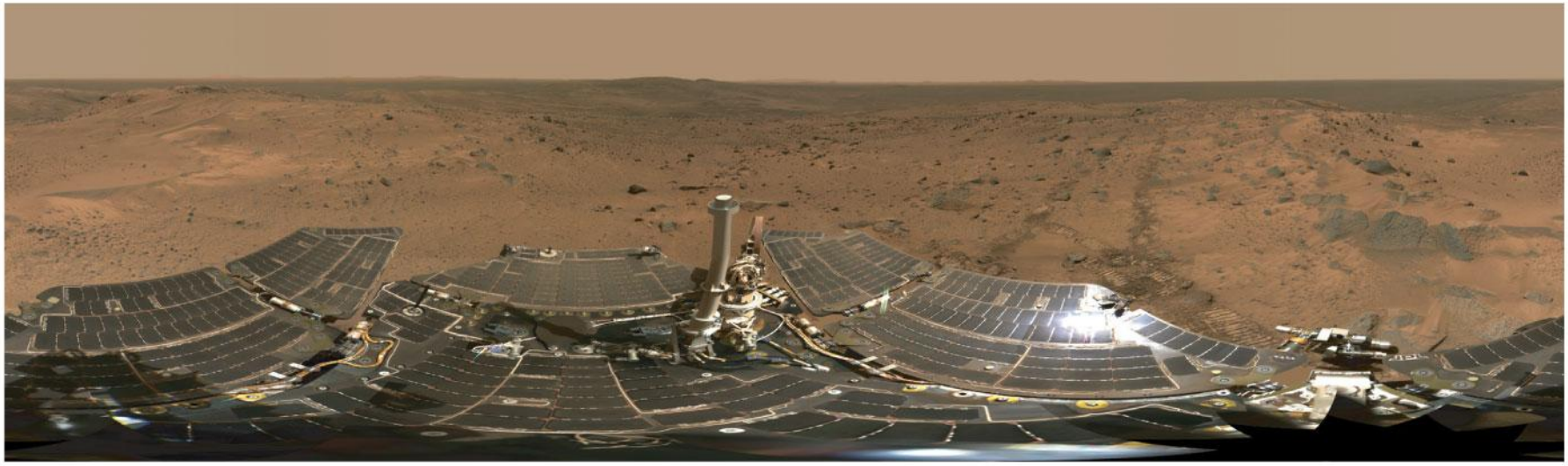
6.1 An Inventory of the Solar System

Now known: Solar system has 166 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)



6.1 An Inventory of the Solar System

More than 400 extrasolar planets have been found

Understanding planetary formation in our own solar system helps understand its formation as well as formation of other systems

6.2 Measuring the Planets

- **Distance from Sun known by Kepler's laws**
- **Orbital period can be observed**
- **Radius known from angular size**
- **Masses from Newton's laws**
- **Rotation period from observations**
- **Density can be calculated knowing radius and mass**

6.2 Measuring the Planets

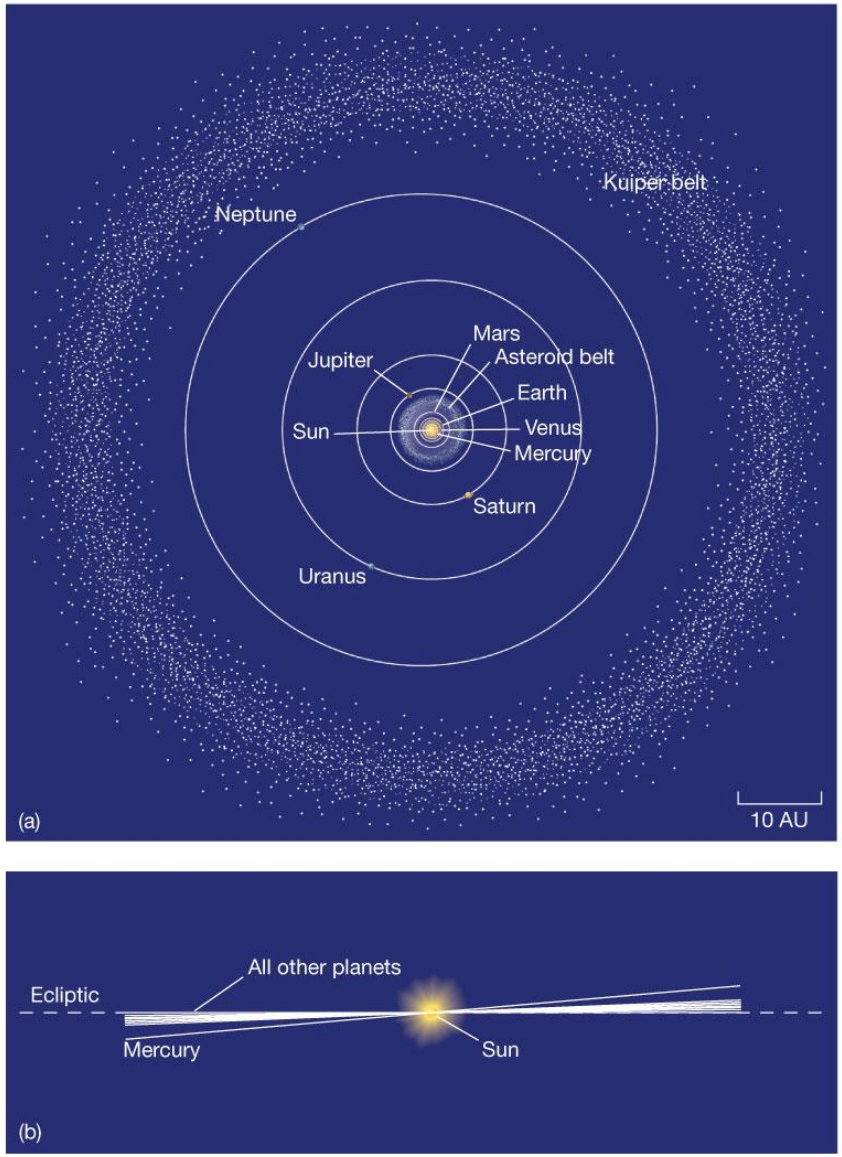
TABLE 6.1 Properties of Some Solar System Objects

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.*

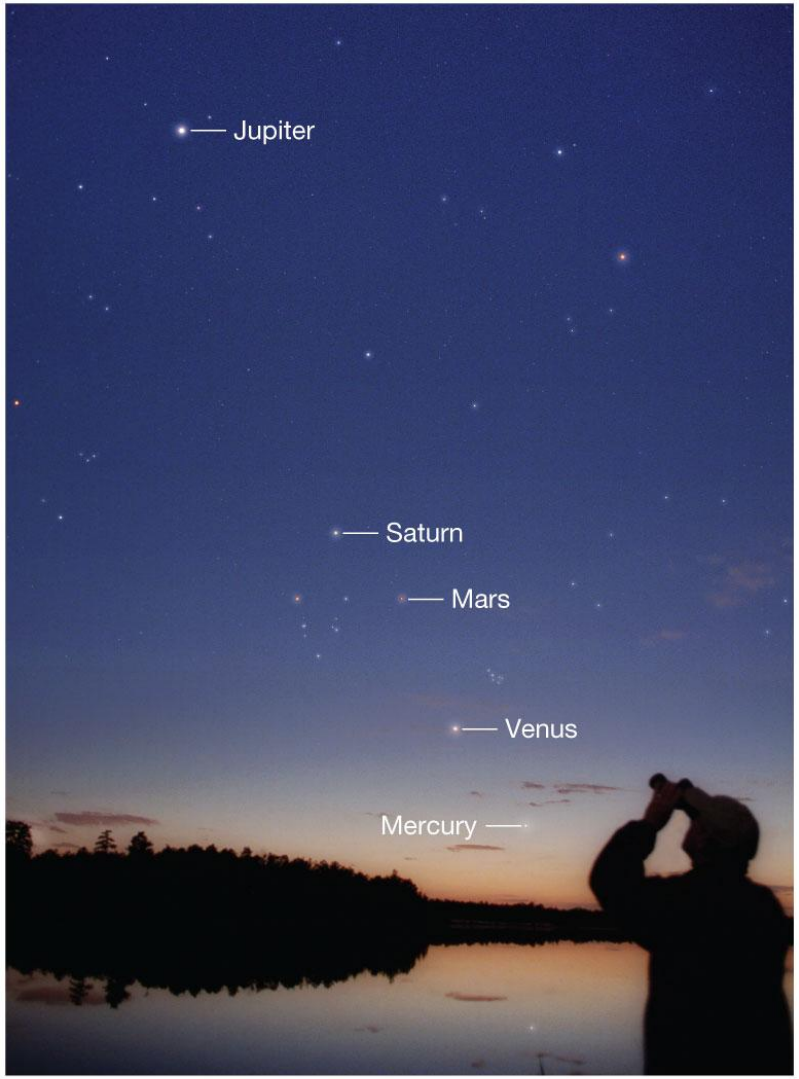
6.3 The Overall Layout of the Solar System

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



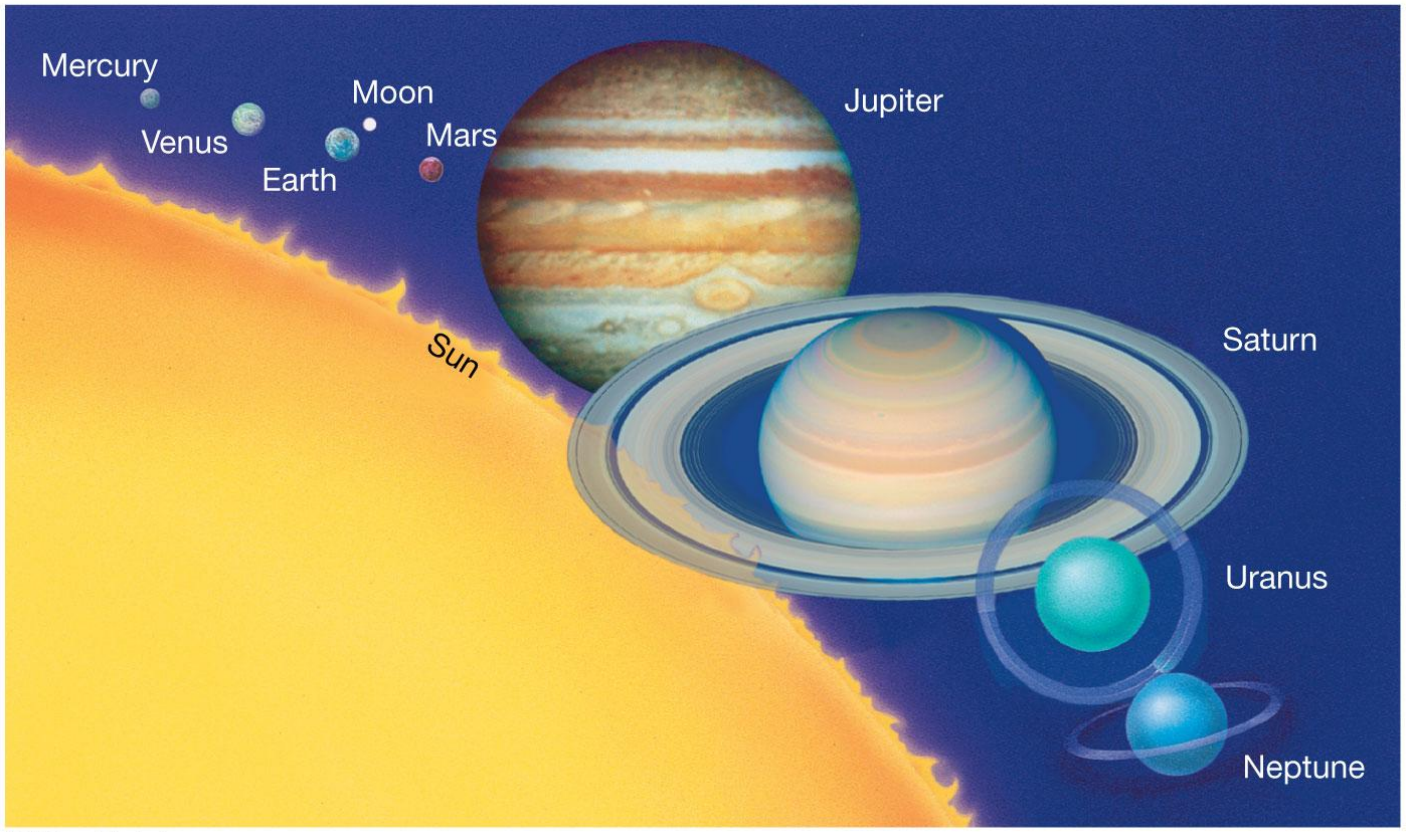
6.3 The Overall Layout of the Solar System

Because the planet's orbits are close to being in a plane, it is possible for them to appear in a straight line as viewed from Earth. This photograph was taken in April 2002.



6.4 Terrestrial and Jovian Planets

In this picture of the eight planets and the Sun, 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

Terrestrial planets are small and rocky, close to the Sun, rotate slowly, have weak magnetic fields, few moons, and no rings

Jovian planets are large and gaseous, far from the Sun, rotate quickly, have strong magnetic fields, many moons, and 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 Earth has oxygen in its atmosphere and liquid water on its surface**
- **Earth and Mars spin at about the same rate; Mercury is much slower, Venus is slow and retrograde**
- **Only Earth and Mars have moons**
- **Only Earth and Mercury have magnetic fields**

6.5 Interplanetary Matter

Asteroids and meteoroids have rocky composition; asteroids are bigger

Asteroid Eros is 34 km long

(a)

6.5 Interplanetary Matter

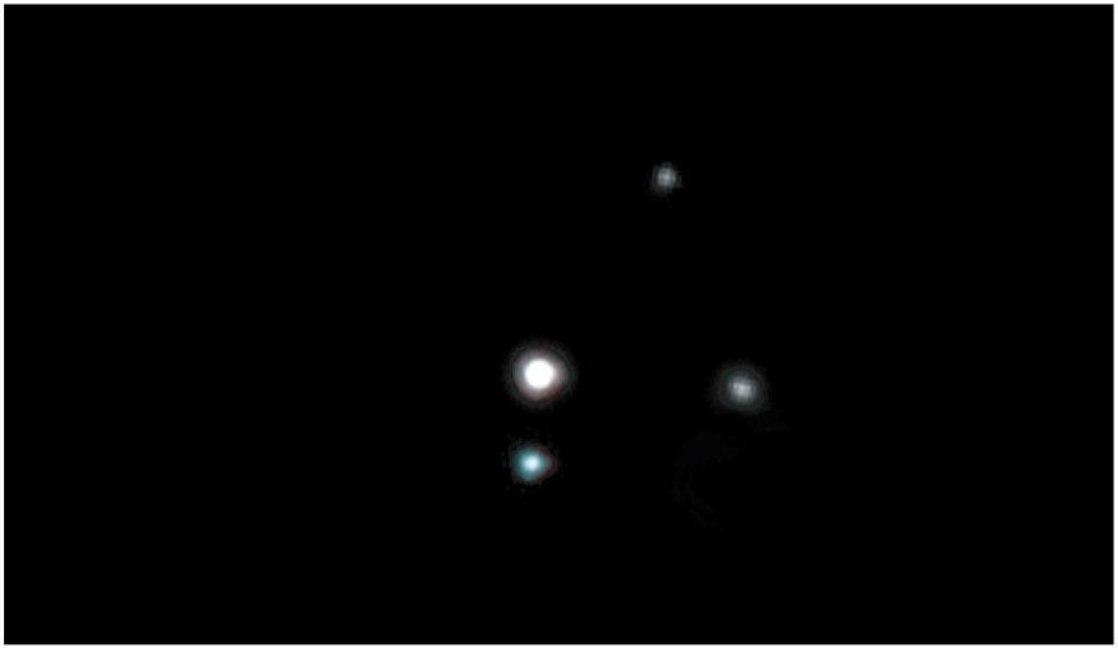
Comets are icy, with some rocky parts

Comet Hale-Bopp

(b)

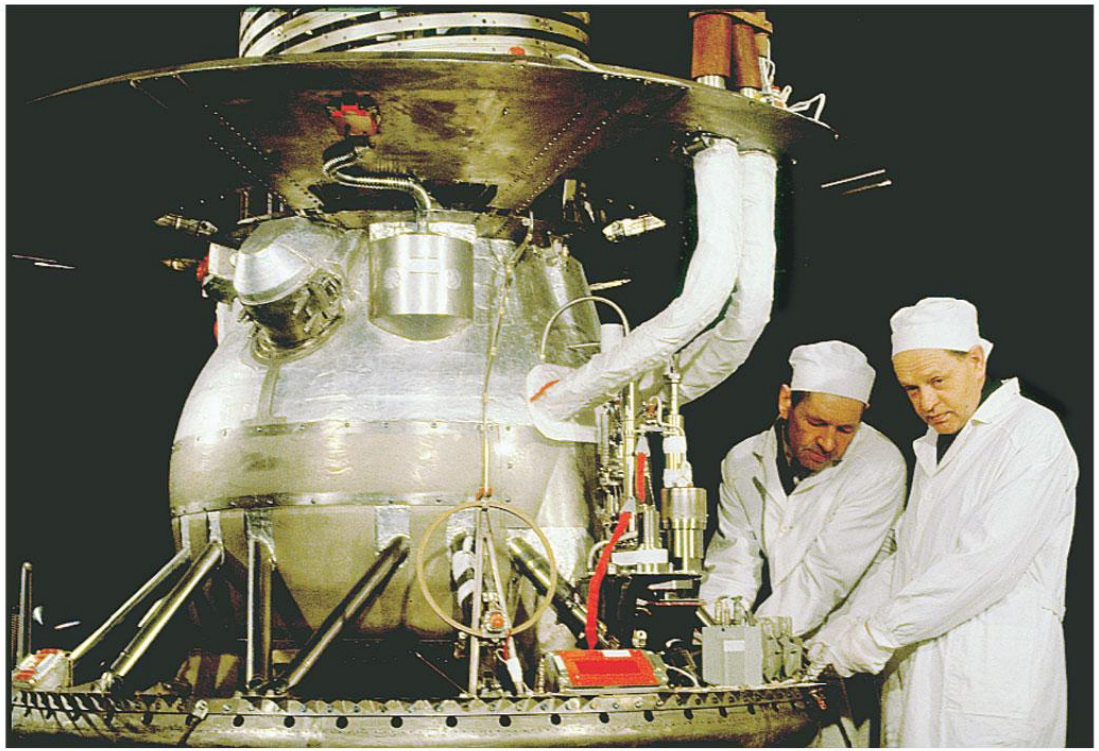
6.5 Interplanetary Matter

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



6.6 Spacecraft Exploration of the Solar System

Soviet *Venera* probes landed on Venus from 1970 to 1978

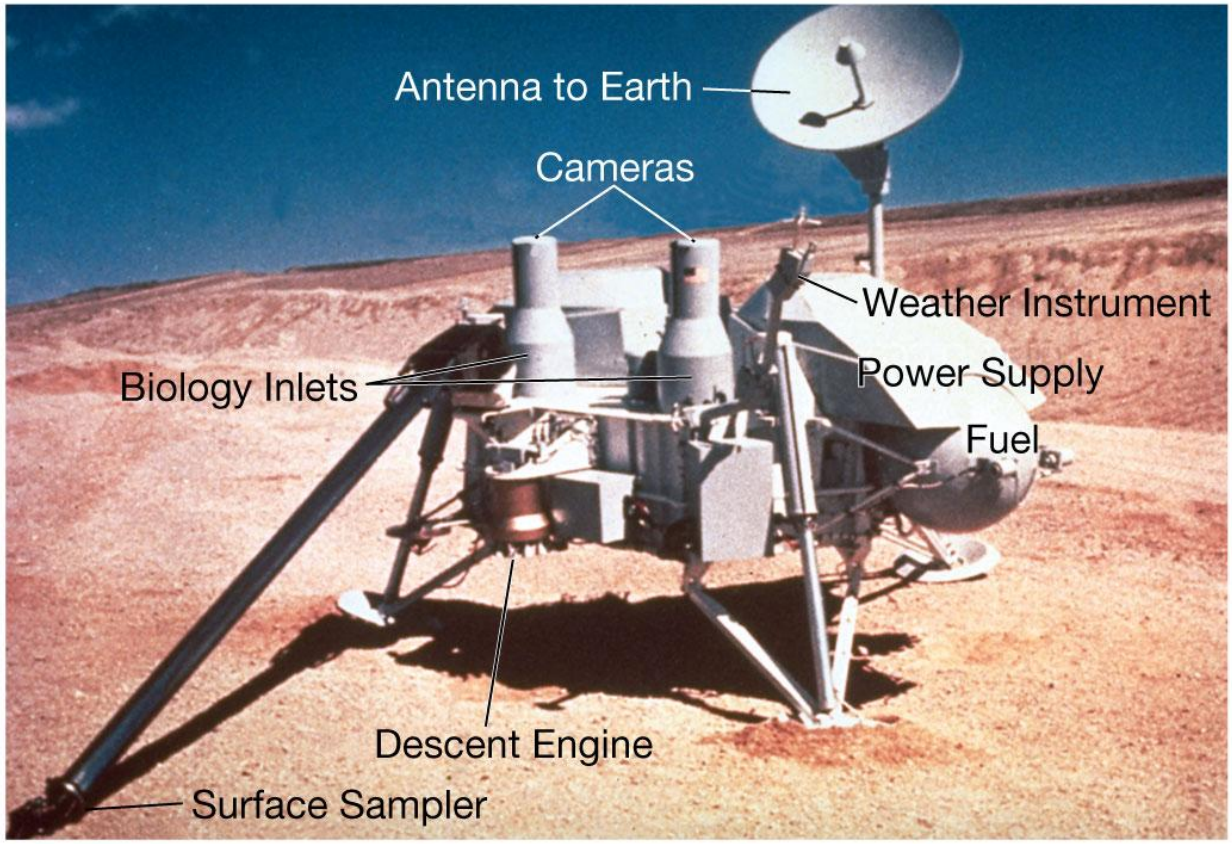


6.6 Spacecraft Exploration of the Solar System

The most recent Venus expedition from the United States was the *Magellan* orbiter, 1990–1994

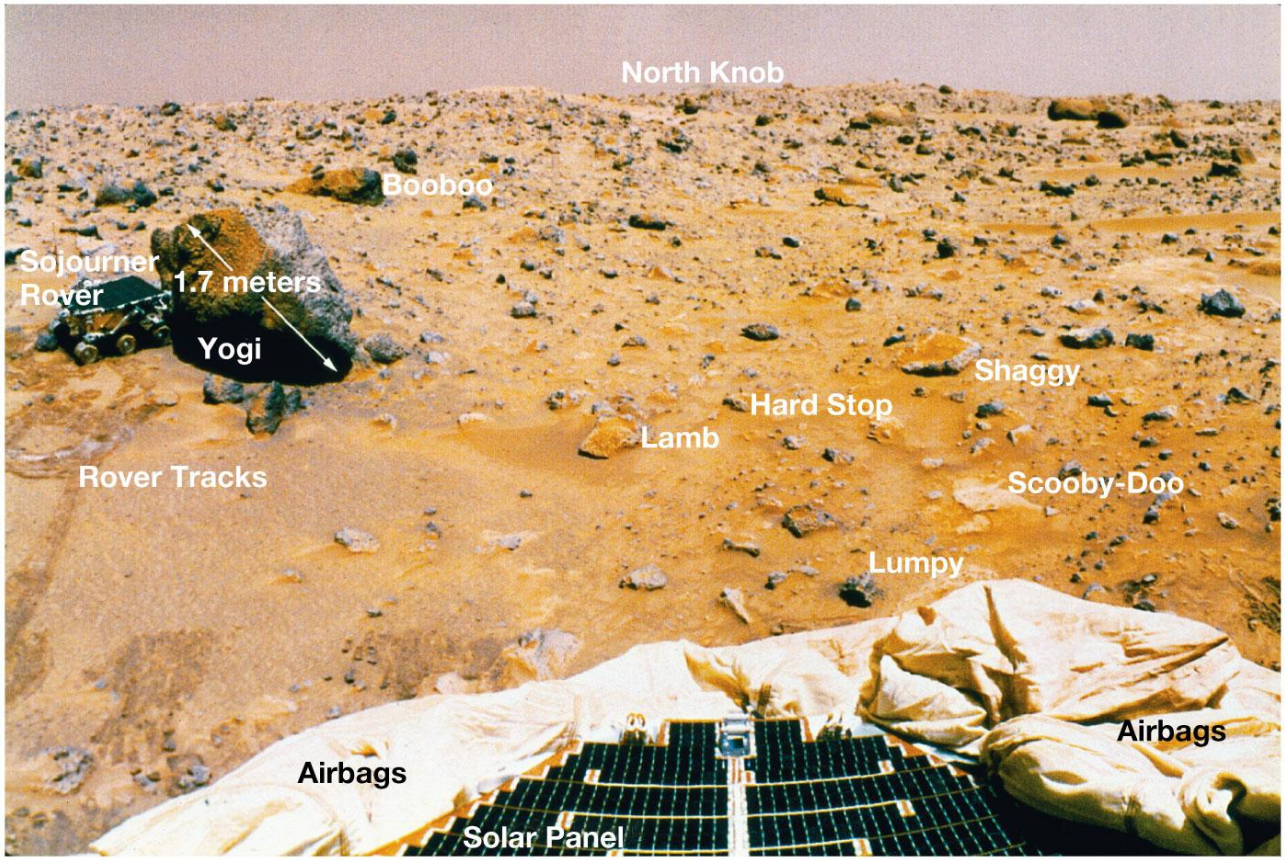
6.6 Spacecraft Exploration of the Solar System

Viking landers arrived at Mars in 1976



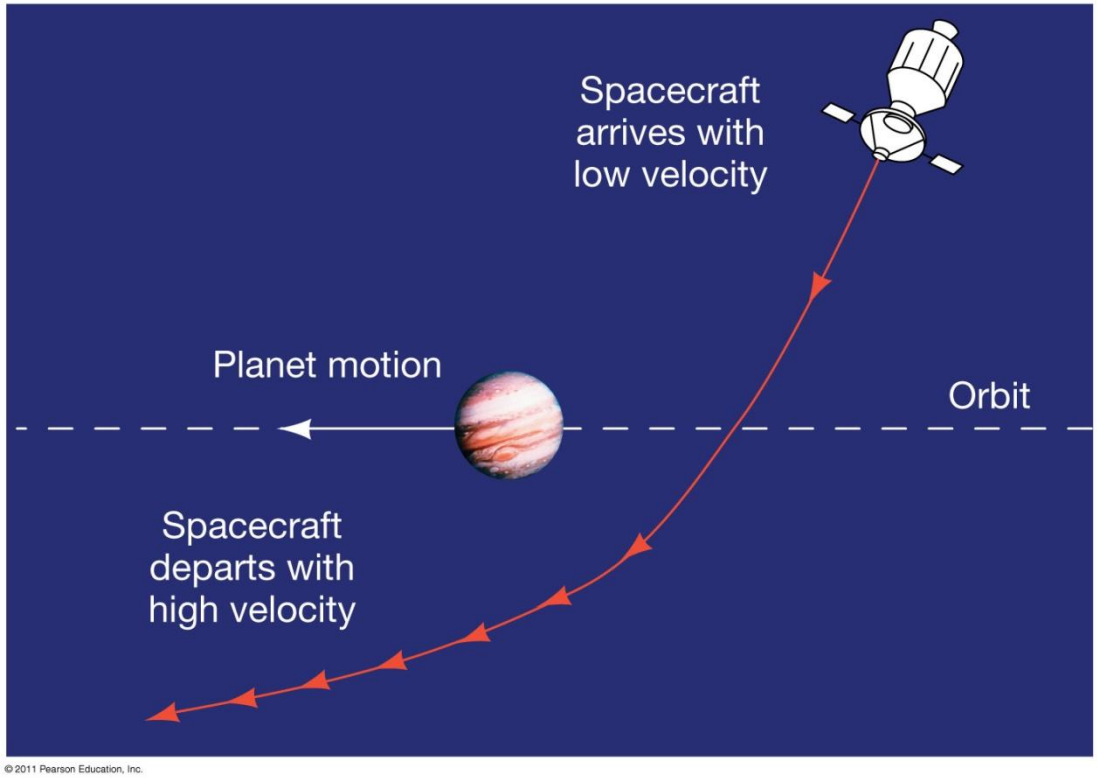
6.6 Spacecraft Exploration of the Solar System

Sojourner was deployed on Mars in 1997



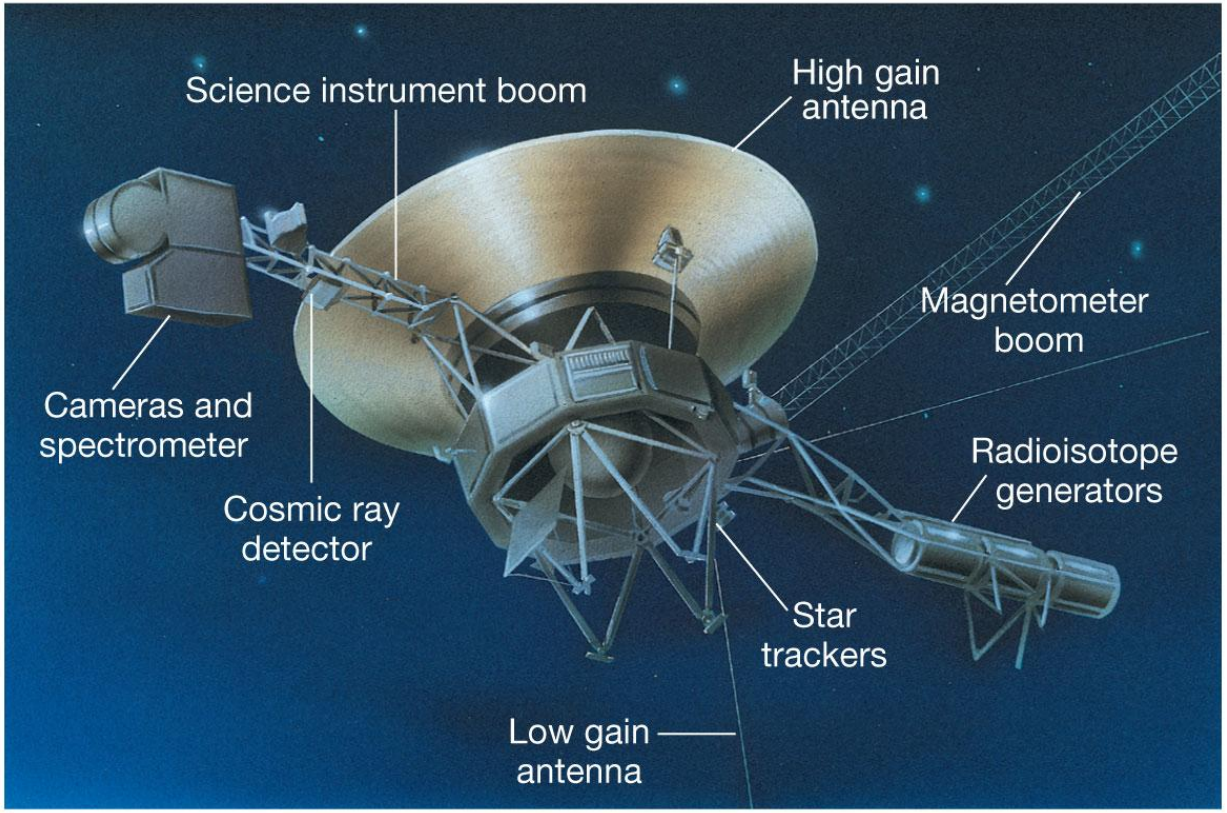
Discovery 6-1: Gravitational "Slingshots"

Gravitational "slingshots" can change direction of spacecraft, and also accelerate it



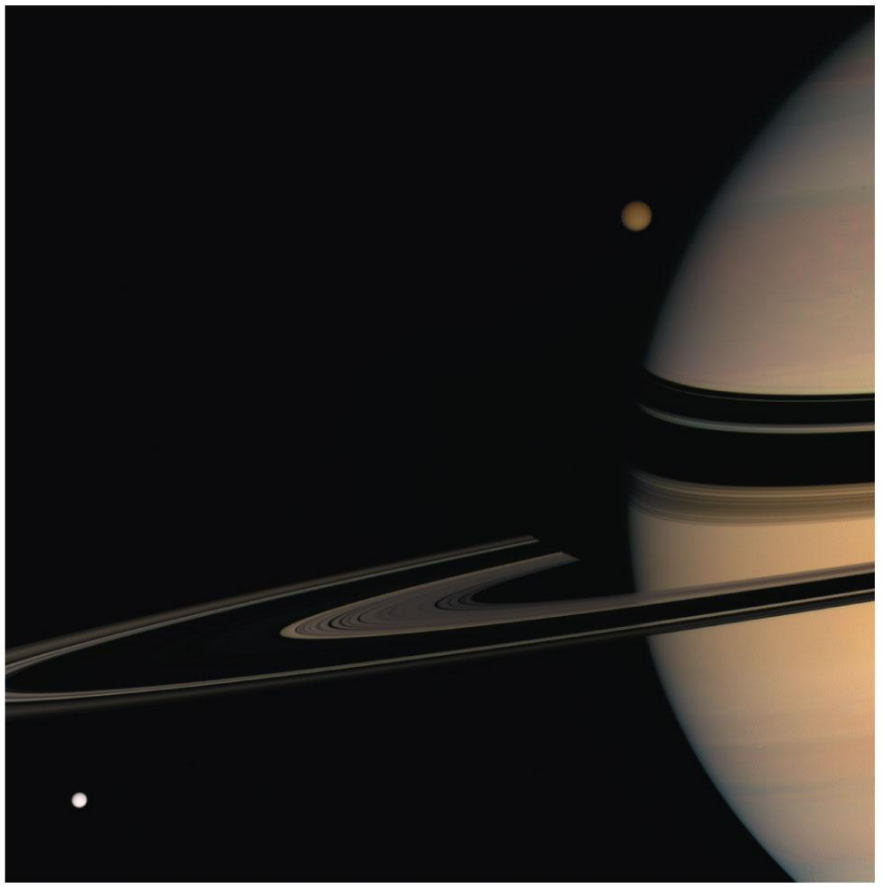
6.6 Spacecraft Exploration of the Solar System

Pioneer* and *Voyager* flew through outer solar system. This is *Voyager.



6.6 Spacecraft Exploration of the Solar System

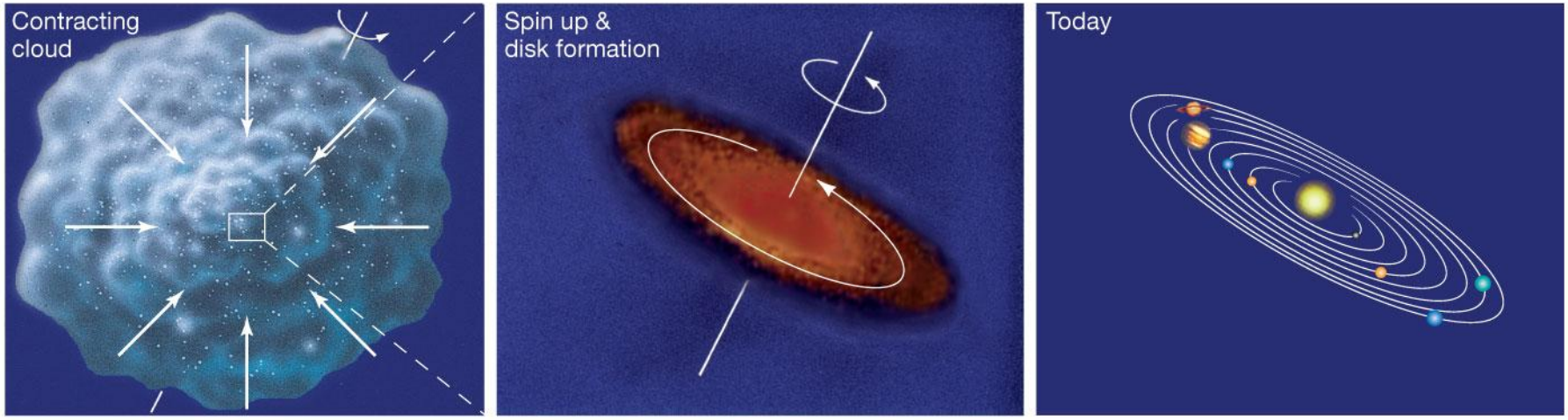
***Cassini* mission arrived at Saturn in 2004, has returned many spectacular images**



6.7 How Did the Solar System Form?

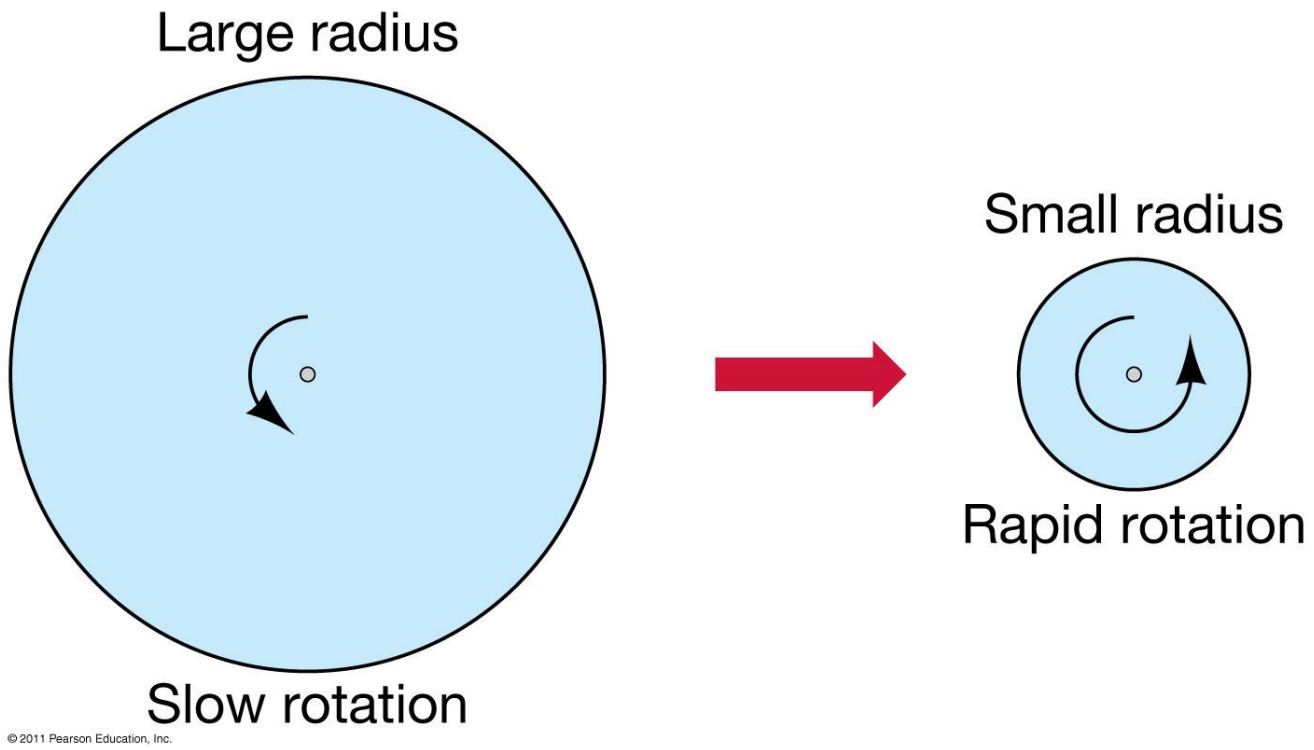
Nebular contraction:

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



More Precisely 6-1: Angular Momentum

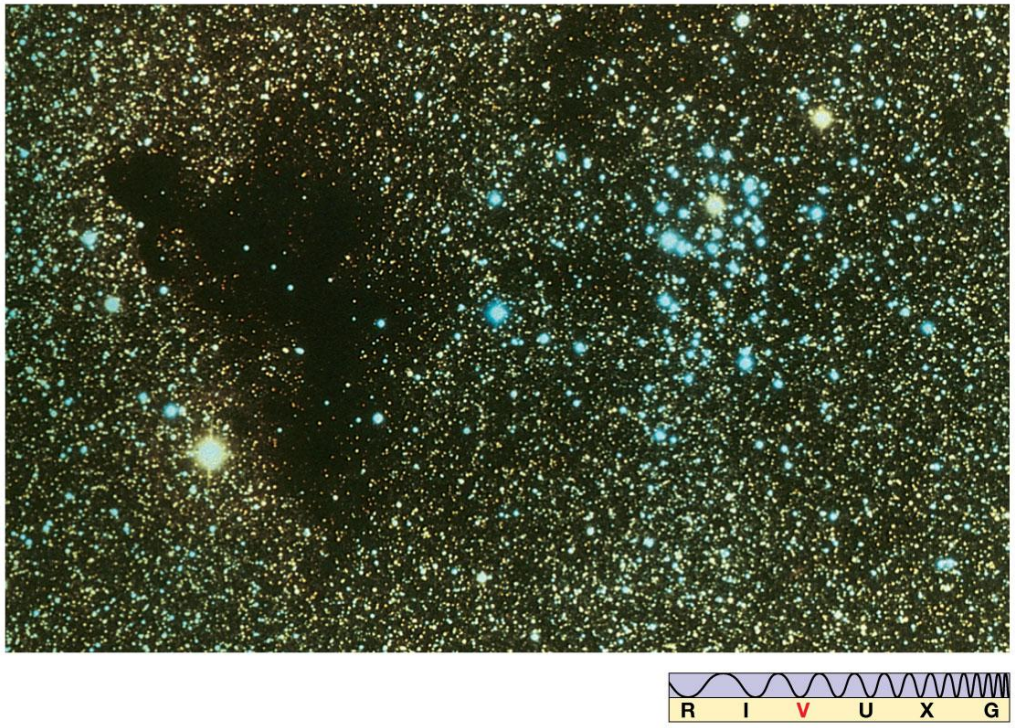
Conservation of angular momentum says that product of radius and rotation rate must be constant



6.7 How Did the Solar System Form?

Nebular contraction is followed by condensation around dust grains, known to exist in interstellar clouds such as the one shown here.

Accretion then leads to larger and larger clumps; finally gravitational attraction takes over and planets form.



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**