Brooks Observatory telescope observing this week

Mon. - Thurs., 7:30 – 9:15 PM MW, 7:30 – 8:45 PM TR

See the class web page for weather updates. This evening’s session is probably being held. cancelled!

Present your blue ticket with your name and my name written on it. If you don’t have a blue ticket, use a sheet of paper.

You are required to attend one session during the semester. You may attend more if you like.

If you attend, a 1/2 to 1-page report/journal is due Wed., Mar. 3.
About Quiz 3

Wed., Feb. 24, 8:30 PM (this evening!)

Telescopes (chapter 5, last Monday)

Solar system overview (chapter 6, last Wednesday)

Solar system formation or origin (chapter 6, Monday this week)

Today, we’ll finish the chapter 6 content and then review.
Summary: explaining the clues to origin

Orderly motions Collapse of a rotating cloud to a disk with a protostar at its center; formation of the planets in the disk.

The original angular momentum of the disk is preserved in the planets’ orbits, the rotation of the Sun on its axis, the direction of the planets’ rotation on their axes, and the direction of the larger satellites’ orbits around their planets.
Terrestrial planets inner, jovian outer Solid materials required to form planets

- Icy materials require low temperatures, found beyond the *frost line*—located approximately at the orbit of Jupiter—to be solid

- Being formed of the most abundant elements (hydrogen, carbon, nitrogen, oxygen), ices provided the biggest supply of planetary raw materials.

- Jupiter and Saturn grew large by accreting solid materials. Then, their gravitational pull was strong enough to sweep up hydrogen and helium gas. That is how they grew as large as they are now.
Comets & asteroids

- Asteroid belt: rapid formation of Jupiter; its gravity prevented formation of a planet
- Oort Cloud comets: icy planetesimals formed near giant planets, gravitational slingshot put them into parabolic orbits
- Kuiper Belt comets: formation mechanism same as for planets, but material thinning out so far from Sun, not enough to form a planet
When the solar system formed—its age

Objects dating from the condensation event: *primitive meteorites*

- Meteorites are chunks of rock that fall to Earth from interplanetary space.
- *Primitive meteorites* are made of tiny grains stuck together. They formed by condensation from a gas.
- Compared to planetary rocks, they are rich in *volatile* substances that are easily driven out by heating.
- Therefore, they have not been modified since they solidified, since modification would involve heating.
Radiometric dating measures the *solidification age* of solid materials.

Certain forms of some elements have nuclei that are unstable and subject to radioactive decay.

- Parent nucleus $\rightarrow$ daughter nucleus + a smaller particle
- Time needed for 1/2 of the parents in a sample to decay is called the *half-life* of the parent nucleus, a definite, constant value measured in the lab
- Example: potassium-40 $\rightarrow$ argon-40, half-life about 1.25 billion years
History of a meteorite grain:

- Potassium-40, half-life 1.25 billion years
- Argon-40, stable

Initial

0.612 billion years

1.25 billion years

1.875 billion years
In meteorites:

- Radioactive potassium atoms “frozen in” to crystals when rock solidified
- Argon does not bind to the same crystals; argon atoms found in potassium-bearing crystal now must have formed by decay of potassium.
- Counting parents & daughters gives the time since solidification.

There are many radioactive parents, each with its own daughter nucleus, giving rise to its own radiometric dating method. Only if at least 3 different methods give the same age for a rock is the age considered reliable.
Radiometric ages of primitive meteorites

- *All* primitive meteorites: $4.56 \pm 0.01$ billion years (measurement error)

- Evidence for solar-system-wide condensation event, motivated nebular theory

- Interpreted as age of solar system, meaning time since first formation of solid material in primordial cloud surrounding infant Sun
Other planetary systems

In about the last decade, about 200 Sun-like stars have been discovered to have one or more planets in orbit around them. The planets themselves are invisible against the glare of their star; they are detected by their gravitational pull on the star. The star’s “wobble” causes a slight Doppler shift. This technique favors low-mass stars and close-in, massive planets. With today’s technology, it would be difficult to detect Jupiter from a distance of 4 light years.
Still, it’s remarkable that the typical planetary system (so far) has a massive jovian planet less than 1 AU from its star.

The planet could not have formed in that location because of the high temperature. Current thinking is that it formed farther out and then migrated inward because of gravitational interactions with numerous smaller planetesimals.

By the same reasoning, Jupiter and Saturn may have formed farther from the Sun than they now are.
20. A planet with a density of more than 5 grams per cubic centimeter is likely to be made largely of:

(a) ice  
(b) rock and ice  
(c) rock only  
(d) rock and iron  
(e) pure iron
19. As a group, the planets that are farther from the Sun than the asteroid belt are ____________ than the planets that are closer.

(a) smaller  (d) denser
(b) larger   (e) rockier
(c) warmer
3. In order to be accepted, a theory on the origin of the solar system must explain why

(a) the planets’ orbits are nearly circular
(b) almost all the planets rotate on their axes in the same direction as they revolve around the Sun
(c) the rocky planets are closest to the Sun
(d) Kepler’s laws apply to the planets’ orbits
(e) more than one of these
6. The origin of the Moon needs a special explanation because

(a) The oldest rocks on the Earth are about the same age as the youngest rocks on the Moon.

(b) The Moon always keeps the same face toward the Earth.

(c) The Moon’s apparent motion is in the same direction as the Sun’s.

(d) The Moon has no atmosphere.

(e) The Earth and the Moon have very different densities—5.5 versus 3.3 grams per cubic centimeter.