Outline 24: History of the Universe and Solar System

The Age of the Universe

- Many published estimates give an age of 14-18 BY old.
- How are these ages determined?

The Age of the Universe

- The study of light from galaxies indicates that the universe is expanding. This is the basis of the Big Bang Theory.
- The velocity of expansion is measured by the amount of Red Shift in the light from other galaxies.

Red Shift of Light Waves

- Light waves are stretched as the galaxies race away from the earth.
- The spectral lines of the visible spectrum are shifted towards the red, or longer, light waves.
- This is an example of the Doppler Effect.

Calculating Expansion Velocity

A spectral line for hydrogen from the sun has a wavelength of λ_0=6562.85A.

- Light from a nearby star in our galaxy shows the same spectral line at λ_1 = 6563.15A.
- Wavelength shift $\Delta\lambda$= 0.30A

Calculating Expansion Velocity

- Velocity = $(\Delta\lambda/\lambda_0)$ x C
- Velocity = (0.30/6562.85) x C

  C = speed of light: 300,000 km/sec

- Velocity = 13.7 km/sec
- So this nearby star is receding from us at 13.7 km/sec.

Calculating Age

- Time = distance/velocity
- e.g., car trip:

  5hrs = 300miles/60 miles/hr.

- The Hydra Galaxy is receding from the earth at 61 x 10^3 km/sec.
- Its distance is 3.96 x10^{22} km

  (4 billion light years)

Calculating Age

- Amount of time the Hydra Galaxy has been traveling?
- Time = distance/velocity
- T = 3.96 x 10^{22} km/61 x 10^3 km/sec
- T = 6.5 x 10^{17} sec (1 year=3.15 x 10^7 sec)
- T = 2.06 x 10^{10} years = 20 BY

20 BY??

- Is the Universe 20 BY old?
- No, gravitational forces have slowed down the galaxies since the Big Bang.
- The present velocities give the appearance that the galaxies have been traveling longer than they actually have.
- Thus the estimates of 14-18 BY.

Origin of our Solar System

- The matter in our solar system is recycled from older stars that exploded as supernovas.
- Early in the history of our galaxy there were large stars that ignited, burned their fuel, and then exploded sending new elements into space.

Life Cycle of a Star

- Small stars: main sequence, red giant, white dwarf. (10 BY years)
- Big stars: main sequence, red giant, supernova. (1 BY years)
- Massive stars: main sequence, red giant, supernova, black hole. (100 MY years)

Life Cycle of a Star

- Main sequence: hydrogen burns to form helium
- Red Giant: helium burns to form carbon, carbon burns to form oxygen, oxygen burns to form iron. All elements lighter than and including iron (56) formed this way.

Life Cycle of a Star

- When a red giant has exhausted its fuel, it collapses inward by gravity.
- This collapse releases so much energy that the star explodes as a supernova.
- Explosive nucleosynthesis produces all the elements heavier than iron (57-260) plus all radioactive elements (except C^{14}).

Supernovas and the Origin of our Solar System

Was the collapse of the nebular dust cloud that formed our solar system triggered by the shock wave from a nearby supernova explosion? The answer seems to be yes.

Supernovas and the Origin of our Solar System

Evidence: Aluminum rich inclusions in meteorites contain the rare isotope Mg 26, which forms by radioactive decay of Al 26. The 1 MY halflife of Al 26 indicates it became part of the meteorite within a few million years (or less) of a supernova explosion.