The Evolution of Matter From The Big Bang To the Solar System

Big Bang \[ t = 0 \]

\[ \downarrow \]

Gamma Rays

\[ \downarrow \]

Production of H (protons), neutrons, electrons complete \[ t = 4 \text{ sec} \]

\[ \downarrow \]

Nuclear Reactions Stop
(Universe in 75% H and 25% He) \[ t = 30 \text{ min} \]

\[ \downarrow \]

Collection of Matter Into Galaxies & Stars \[ t = 1 \text{ billion years} \]

\[ \downarrow \]

massive star \[ \text{Ism} \equiv \text{interstellar medium} \]

\[ \text{Supernova} \]

\[ \text{Star Formation From IZM} \]

\[ \text{Decay Elements Into IZM} \]

\[ \text{C, O, N, Ca in your body cooked up (fusion) inside massive stars} \]

\[ \text{Elements heavier than iron created during supernova explosion} \]

\[ \downarrow \]

Formation of the Sun, Earth, Solar System \[ t \approx 10 \text{ billion years} \]
Origin and Evolution of the Solar System

I. Observed Properties

a. Dynamics

1. Revolution and Rotation

- All planets revolve counterclockwise around Sun
- All planets (except Venus, Pluto, Uranus) rotate counterclockwise on their axes.

2. All planets orbit in the same plane about the Sun

b. Composition

Rocky mantle

1. Terrestrial Planets (Mercury, Venus, Earth, Mars)

- Located in the inner solar system
- Small, dense, rocky, scarred by impact craters
- Iron-nickel core, surrounded by mantle of dense rock
  density $= 3 - 5 \text{ g cm}^{-3}$

2. Jovian Planets (Jupiter, Saturn, Uranus, Neptune)

- Located in the outer solar system
- Large, low-density
- Hydrogen-rich bodies, low-density (less than 1.75 g cm$^{-3}$)
1. Asteroids
   - orbit in belt between Mars and Jupiter
   - small rocky worlds
     - 20,000 have been identified
     - 1,000 come into inner solar system, can collide with a planet.
   - asteroid belt are the remains of a planet that failed to form

2. Comets
   - nucleus is a ball of dirty ice, only a few dozen km in diameter
   - icy bodies left over from the origin of planets
   - on elliptical orbits about sun
   - vaporization of icy nucleus to form coma & tails
     - only near the sun, snowball with no coma & tail away from the sun.
   - come from Oort Cloud and Kuiper Belt

3. Meteors (Shooting Stars)
   - small bits of rock & metal
   - meteors are from comets
   - meteorites are from asteroids
II. Explanation of Observed Properties of Solar System

a. Dynamics

1. Collapse of large cloud of gas and dust in dense molecular cloud.

   ![Diagram of gas cloud with composition]

   - 75% H
   - 25% He
   - 2% metals

2. Explains revolution & rotation of planets and confinement to disk
b. Composition

1. Condensation Sequence
   (Nebular Gas of H, He, C, O, N, Si, Ni, Fe, Mg....)

   \[ \begin{array}{ccc}
   1500 \text{ K} & 750 \text{ K} & 150 \text{ K} \\
   \end{array} \]

   Composition of Grains
   - metals
   - metal oxides
   - Silicates (Rocks)
   - metals
   - metal oxides
   - Ice

C. Space Debris

1. Asteroids, comets, meteoroids are leftover material from the formation of the planets