Earth & Space Science

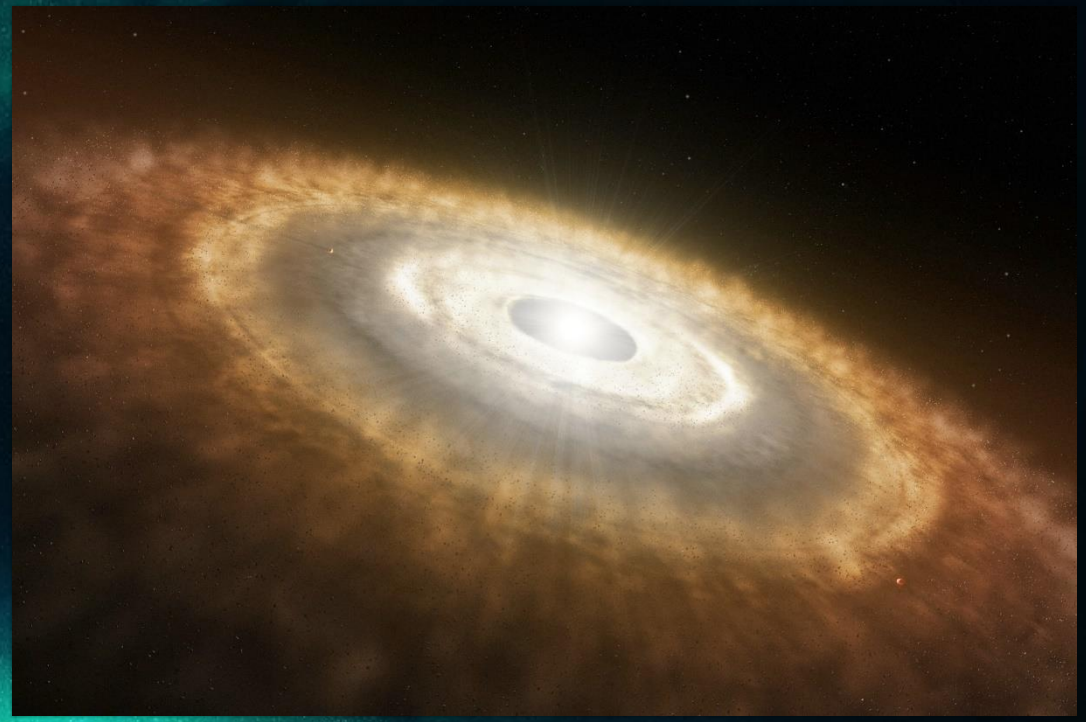
Unit 2 – Lecture 1: Formation of the Solar System

Disclaimer

- This is an active area of research--different people are working on different parts of the story. Some are building computer models of the physics and chemistry--others are searching for clues of conditions in the early solar system by exploring the more primitive bodies--comets, meteoroids and asteroids. Others are looking for solar systems around other stars to see if there is a range of different kinds of solar systems that can form.

Review

- Remember that during the formation of the protosun that the majority of the matter from the nebula was drawn to the center
- The matter that was left out of the center accumulated into a flattened disc that rotated about the protosun
- Once nuclear fusion took place strong solar winds blew away the remaining nebula away

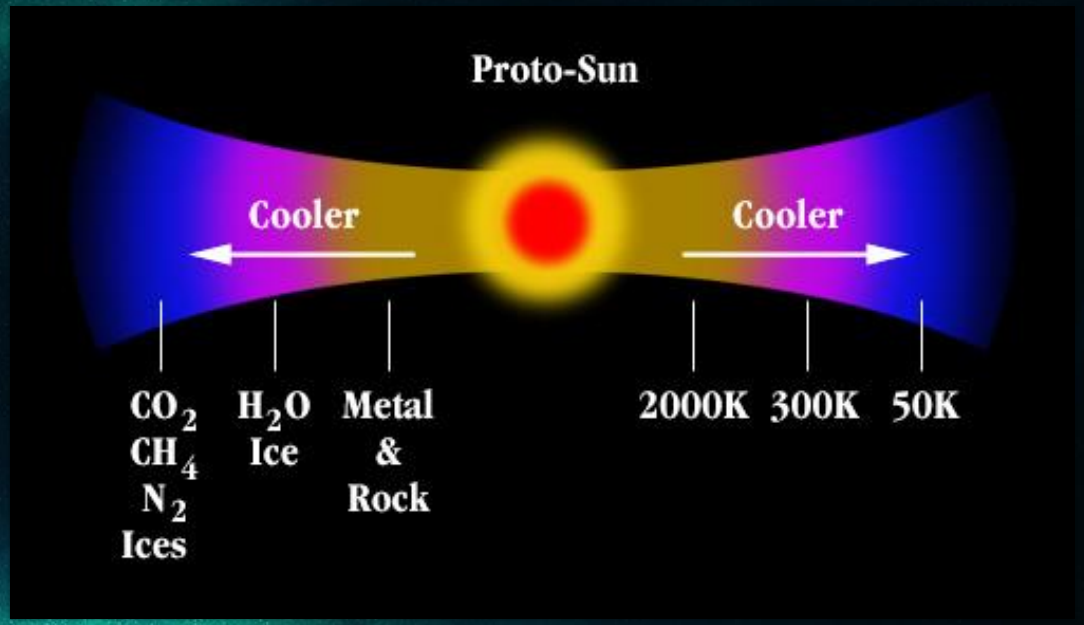


The Beginning Stages

- The solar system formed 4.5 billion years ago
- A clump of interstellar material (hydrogen, helium, molecules and dust) collapses under self-gravity to for a protosun and a surrounding disk.
- As the nebula collapses it
  - Heats up - eventually nuclear reactions are initiated in the sun
  - Spins up - conserving angular momentum

The Beginning Stages (cont.)

- The sun must have lost most of its angular momentum - 2 possible ways:
  - A period of strong solar wind
  - Interaction of the sun's magnetic field with ionized material in the disk, braking the sun's rotation
- There was a strong temperature gradient in the disk nebula:
  - Close to the sun everything remained vaporized except refractory materials
  - Outside 3-4 AU ice grains condensed (called the "snowline"



The Middle Stages

- The outer disk collapsed from a larger volume, providing
  - More material
  - More planetesimals
- As the nebula cooled
  - Close in - only refractory materials condensed => terrestrial planets
  - Farther out more and more volatile material condensed => ices
- Planetesimals collide and accrete to form planets:- in the outer solar system more material => larger planets which were able to gravitationally bind lighter gases (hydrogen and helium)

The Final Stages

- Period of strong solar wind blew away remaining gas in the nebula disk
- The objects that did not accrete to form large enough bodies to differentiate retain the chemical composition of the original condensed solar nebula. Thus we believe the oldest meteorites (and comets, should we ever get to sample them) hold clues about the early phases of solar system evolution.
- Jupiter kept perturbing the orbits of the planetesimals inside Jupiter - the planetesimals kept crashing into each other at too high speed to coalesce - they broke up instead. These objects formed the asteroid belt.

The Final Stages

- Conditions in the proto-Jupiter nebula mimics the solar system: satellites closer to Jupiter are rocky while farther satellites have more ice (and lower density).
- Some of the remnant planetesimals were captured by the giant planets to form the irregular satellites.
- Comets from the outer solar system bring volatiles in to the terrestrial planets (=> atmospheres of terrestrial planets)