Astronomy 113
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Star Formation
Gas and dust lying between stars (10% of the mass of our galaxy)

Hydrogen is the most abundant element

Observe molecules too: H$_2$O, CO, Ammonia, Hydrocarbons, Amino Acids, Alcohols

ISM is found in different states: hot, warm, & cold
**Giant Molecular Clouds**

- Very cold, “dense” gas/dust clouds
- Masses ~ $10^6 \ M_\odot$
- ~ 100 ly in diameter
- 74% H, 25% He, 1% other **

**“Heavy” elements, or “metals” = all elements heavier than H**

GMCs are important because they are what stars form from

When they are compressed:
1. By cloud-to-cloud collisions
2. By supernova explosions

Star formation is initiated

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Giant Molecular Clouds

- Insert element chart / abundances....

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1. Cold, dense cloud starts to collapse gravitationally
   ✦ One cloud may form many stars (“open” cluster)
   ✦ The dense core (protostar) collapses quickly as more material “accretes” onto it

2. After $10^5$ yrs, mass builds to $\sim 1 \, M_\odot$
   ✦ Core heats through the release of gravitation potential energy
   ✦ Radiation pressure stops accretion
   ✦ Protostar $\rightarrow$ pre-main-sequence star which contracts due to gravity
3. When the core reaches $T \sim 10^7$ K, fusion starts and radiation pressure halts contraction.

4. Outer shell of gas/dust is blown off and we have a new star.
The star’s mass places it on the H-R diagram.

- If $M \lesssim 0.08 \, \text{M}_\odot$ - Core doesn’t heat enough to start fusion
  - Brown Dwarf (slightly more massive than Jupiter)
- If $M \gtrsim 100 \, \text{M}_\odot$ outer envelop is blown off, and star is disrupted
Nebula

- Hot O & B stars have lots of ultraviolet radiation and they ionize the surrounding nebula.
- Recombination makes the nebula glow (emission nebula).
- Because they are made of ionized H, we also call them HII regions (for singly ionized H).
Star Clusters

- Ionization shell/Supernovae compress gas leading to star formation
- Strings of star clusters of increasing age in large star forming regions
- By plotting stars in clusters, can determine age (more later)
Star Clusters

- Add image of star formation sequence
Gas clouds collapse (100,000 yrs)
Stars form all together - cluster
Most massive ones use fuel fastest (1 million yrs)
Least massive live a longest (100 billion yrs)
Extrasolar Planetary Systems

- Newly formed stars everywhere with gas/dust clouds and disks
- Planets form everywhere
- 164 extrasolar planets found as of November 2005

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Proplyds