Today: Star Birth

- Look at how stars are formed out of big and cold molecular clouds
- Review 17.2 Star Birth (and handout Chap 16 from 4 ed)
- Read Chap 16 Properties of Stars
- Review session Thursday, 7-9pm, sheets available

Reading Clicker – Protostars

Angular momentum plays an important role in star formation. Which aspect is probably NOT affected much by star’s original angular momentum?

- A. Protostellar winds
- B. Onset of core hydrogen fusion
- C. Protostellar jets
- D. Protostellar disks

B.

STAR BIRTH within big cold clouds

Start with clouds of cold, interstellar gas

- Molecular clouds – cold enough to form molecules T=10-30K
- Often dusty
- Collapses under its own gravity

Recurring theme in forming stars: Conservation of energy and angular momentum

- 1. Collapse due to gravity increases the temperature. If thermal energy can escape via radiation (glowing gas), collapse continues
- 2. If thermal energy is trapped, or more energy is generated due to fusion, collapse is slowed
Collapse from Cloud to Protostar

- First collapse from very large, cold cloud – cold enough to contain molecules (molecular clouds)
- The cloud fragments into star-sized masses
- Temperature increases in each fragment as it continues to collapse

Dusty, dark molecular cloud regions

Stellar nurseries start as cold places

Gravity, Spin, Magnetic Fields

Star Birth Movie
1. Collapsing protostar is first shrouded by cocoon of dusty gas, but then winds and jet blast through.

Collapsing cloud spins up, forms star, disk and jet.

Jets from young stellar objects (YSOs)

A jet from a young star

HST 1997 - 1994
2. Collapse continues, temperature stabilizes as deep convection circulates energy outwards

3 → 4: As core temperatures reach millions of degrees, fusion begins and stabilizes – star joins main sequence

Protostars of different masses follow different life tracks toward MS

More massive stars go more quickly, and nearly horizontally across H-R diagram

Life now begins on "zero-age main sequence" (ZAMS)

Clicker – starbirth and color

For every massive O-star that is born, there are ~100 low-mass M-stars also born!

• 1 blue O → 100 red M
• Lum O = 10,000 solar luminosities
• Lum M = 0.001 solar luminosities

What color is the starlight from the star forming spiral arms in our galaxy?

• A. Blue
• B. Red
• C. Orange

Galaxy color

• A. Blue
• 100 times more M stars, but each is 1 / 10,000,000 times fainter than an O-star
• Massive blue stars dominate the light

Galaxy color
**Stellar nurseries yield lovely sights**

- Hot new blue main sequence stars
- Pink hydrogen gas
- Black sooty dust
- Blue nebulae are reflections of starlight from massive blue stars

**The Orion Star Forming Complex**

Comparing different emission features

Infrared view of winter sky (10 - 120 μm)

Optical view of winter sky

Visible

Orion Molecular Clouds as seen in radio emission (very zoomed in)

Eagle Nebula: cold dark clouds are eroded by intense starlight

Orion Nebula