ASTR 1120: Stars & Galaxies

Pleiades

Prof. Juri Toomre TA: Ben Brown
Lecture 20 Fri 25 Feb 05
zeus.colorado.edu/astr1120-toomre

Today: Star Birth

- Look at *how stars are formed* out of <u>big and cold molecular clouds</u>
- *Homework Set 5* due today (boxes outside)
- *New Homework Set 6* available
- Read *17.4 Life as a High-Mass Star*
- *Begin overview read Chap 18 Bizarre Stellar Graveyard*

Reading Clicker – Protostars

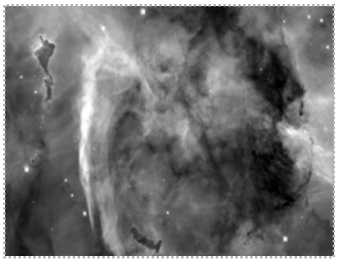
- *Angular momentum plays an important role in star formation. Which aspect is probably <u>NOT</u> affected much by star's original angular momentum?*

B.

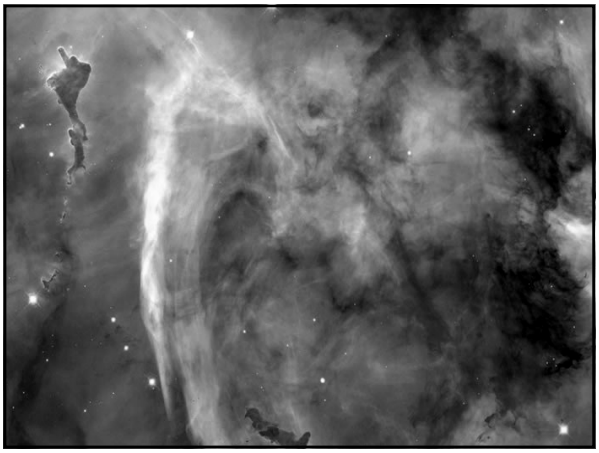
- A. Protostellar winds
- B. Onset of core hydrogen fusion
- C. Protostellar jets
- D. Protostellar disks

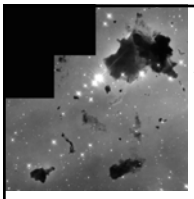
<u>STAR BIRTH</u> within big cold clouds

Start with clouds of cold, interstellar gas



- *<u>Molecular clouds</u> -- cold enough to form molecules T=10-30K*
- *Often dusty*
- *Collapses under its own gravity*

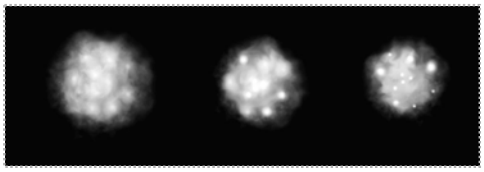




Recurring theme in forming stars:
Conservation of <u>energy</u> and <u>angular momentum</u>

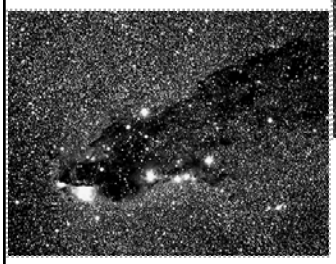
- *1. Collapse due to gravity <u>increases the temperature</u>. If thermal energy can escape via radiation (glowing gas) , collapse continues*
- *2. If <u>thermal energy is trapped</u>, or more energy is generated due to fusion, collapse is slowed*

Collapse from Cloud to Protostar

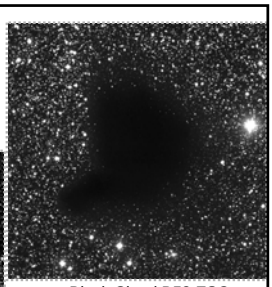


- *First collapse from very large, cold cloud – cold enough to contain molecules (molecular clouds)*
- *The cloud fragments into star-sized masses*
- *Temperature increases in each fragment as it continues to collapse*

Dusty, dark molecular cloud regions

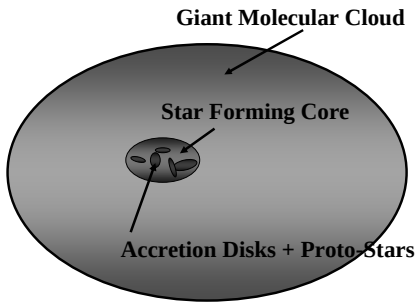


Star birth in Scorpius AAT

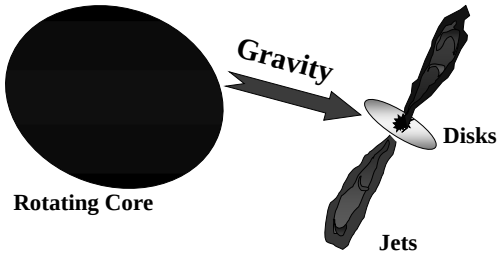


Black Cloud B58 ESO

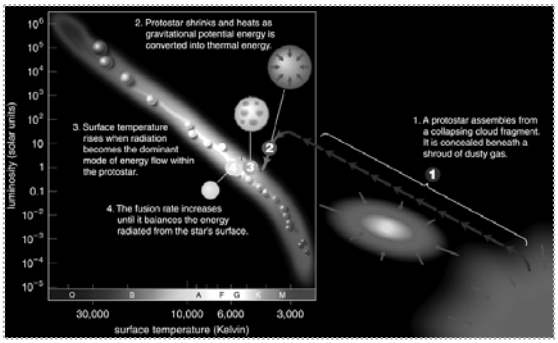
Stellar nurseries start as cold places



Gravity, Spin, Magnetic Fields

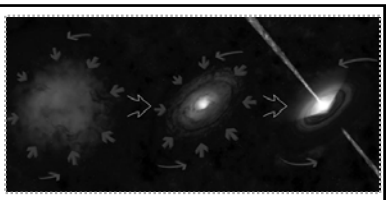


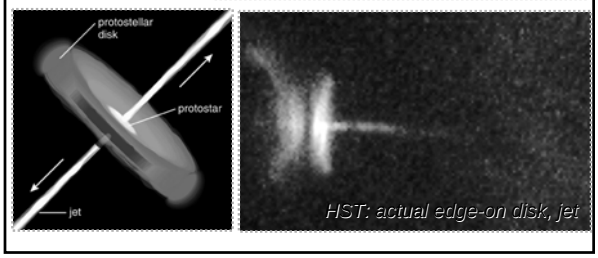
STAR FORMATION MOVIE



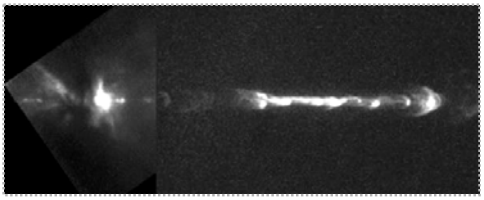
1 → 2: Collapsing protostar is first shrouded by cocoon of dusty gas, but then winds and jet blast through

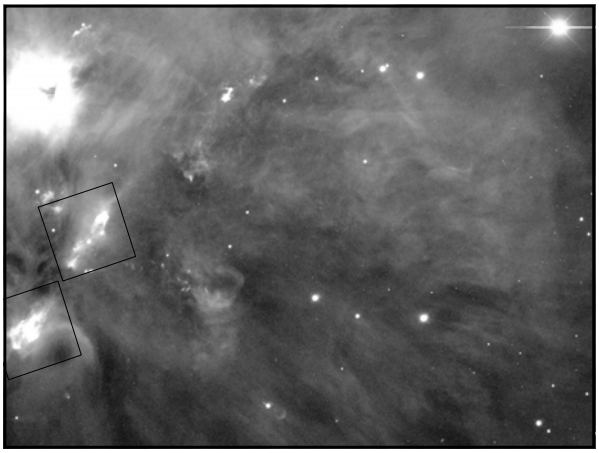
Collapsing cloud <u>spins up</u>, forms star, disk and jet



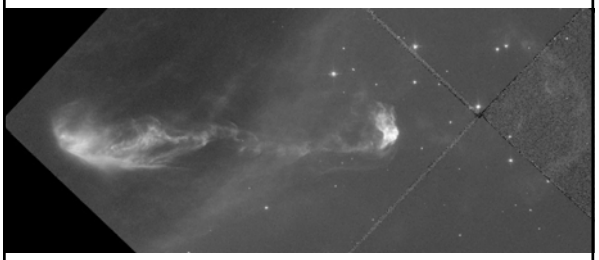


Jets from young stellar objects (YSOs)



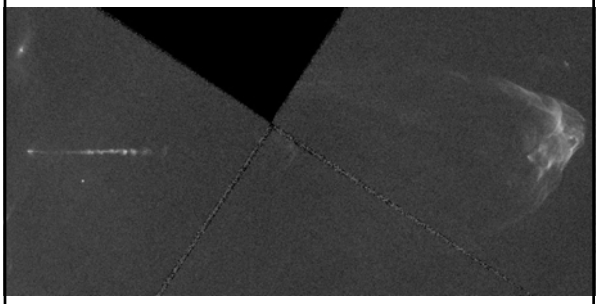


A jet from a young star

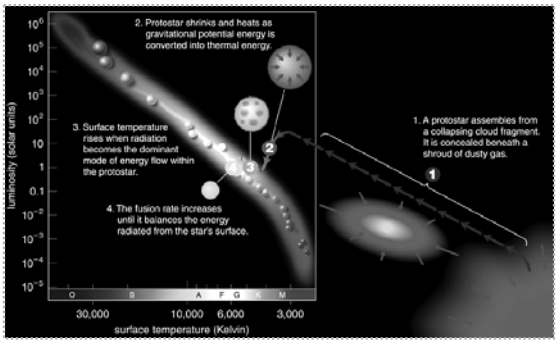


HST 1997 - 1994

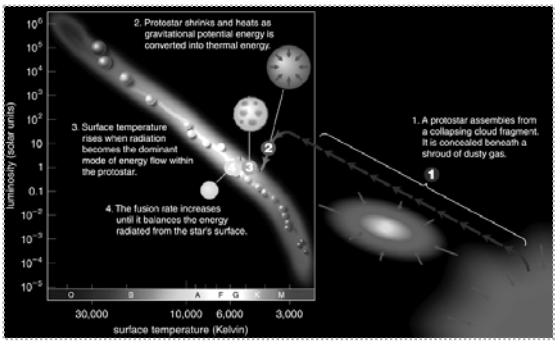
A jet from a young star



HST 1997 - 1994



<u>2:</u> Collapse continues, temperature stabilizes as deep convection circulates energy outwards

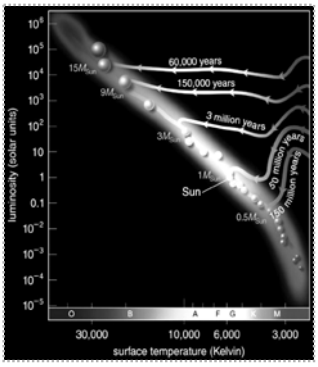


3 → 4: As core temperatures reach millions of degrees, fusion begins and stabilizes – star joins main sequence

Protostars of different masses follow different life tracks toward MS

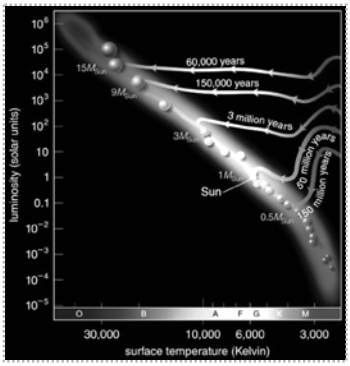
More massive stars go more quickly, and nearly horizontally across H-R diagram

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



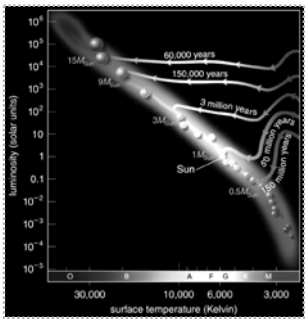
Clicker – starbirth and color

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



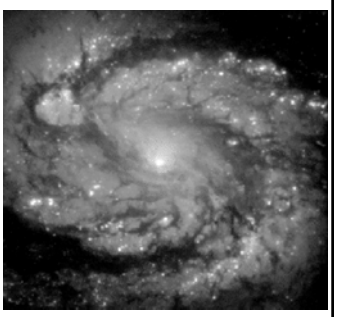
Galaxy color

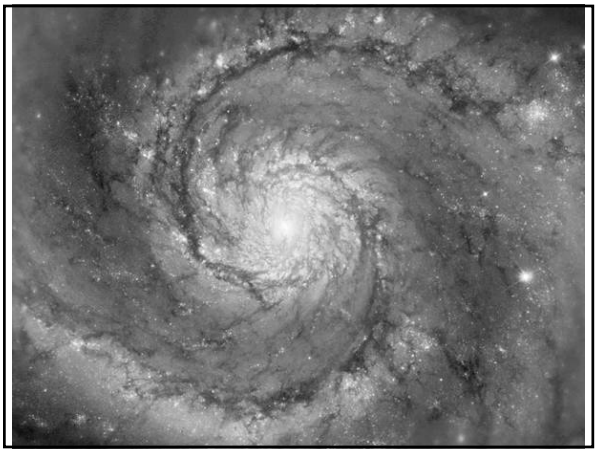
- *1 blue O → 100 red M*
- *Lum O = 10,000 solar luminosities*
- *Lum M = 0.001 solar luminosities*
- *What color is the starlight from the star forming spiral arms in our galaxy?*
- *A. Blue*
- *B. Red*
- *C. Orange*

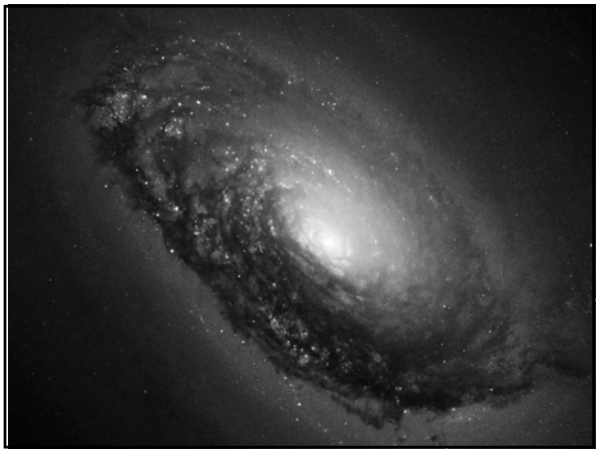


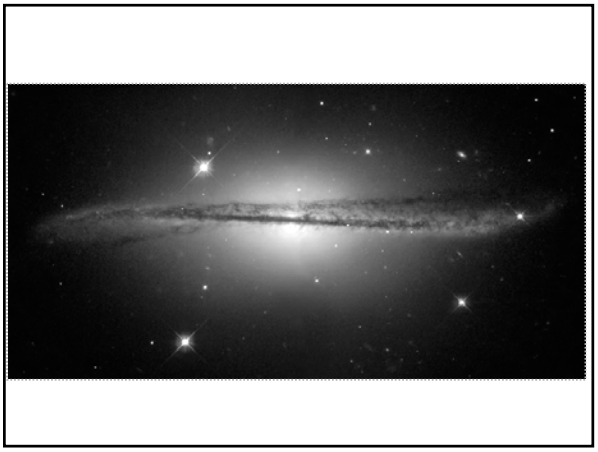
Galaxy color

- *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*





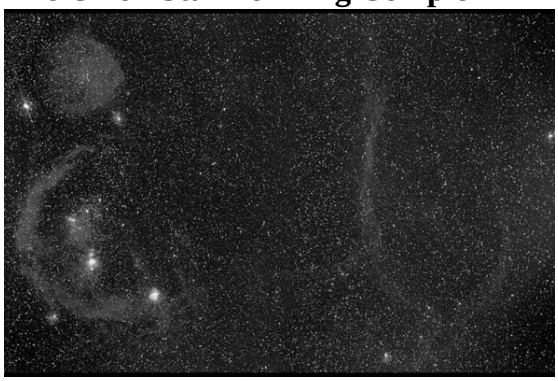




Stellar nurseries yield lovely sights

- *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

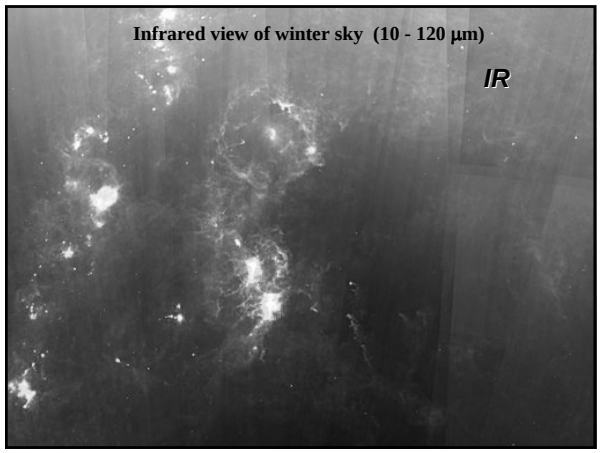


Optical view of winter sky

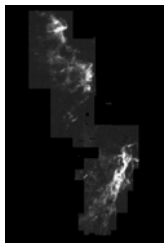
Visible

Infrared view of winter sky (10 - 120 μm)

IR



Radio



Eagle Nebula: cold dark clouds are eroded by intense starlight