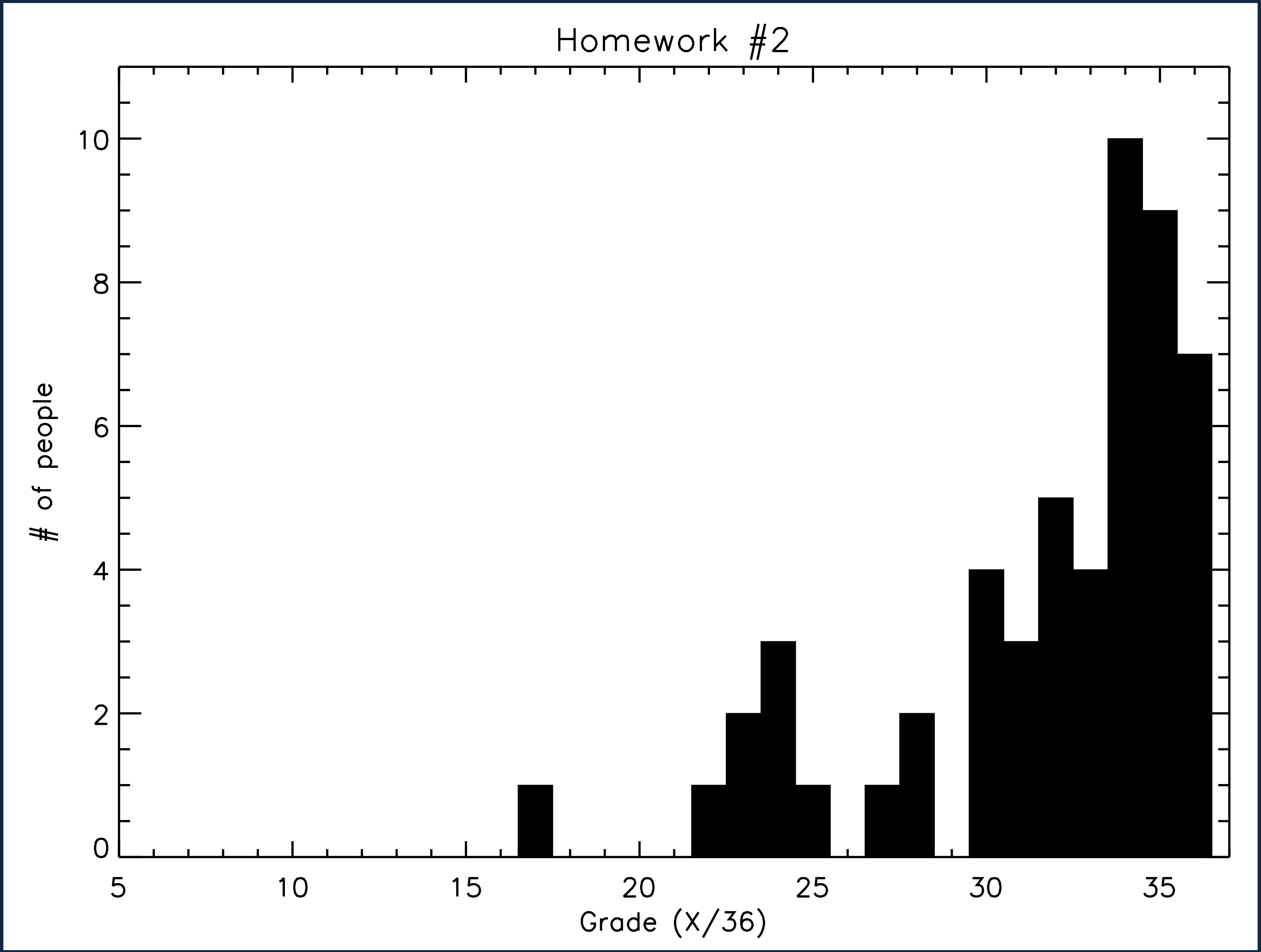
Homework #2



Exam #1

will be returned on Tuesday

Exam #1

Combined Apparent Magnitude

$m_1 = 4,\ m_2 = 3$ $\qquad$ $m_2 - m_1 = -2.5\log(f_2/f_1)$

$$-1 = -2.5\log(f_2/f_1)$$

$$0.4 = \log(f_2/f_1)$$

$$2.5 = f_2/f_1$$

$$\text{so } f_2 = 2.5f_1,\ f_1 + f_2 = 3.5f_1$$

$$m_2 - m_{1+2} = -2.5\log(2.5\cancel{f_1}/3.5\cancel{f_1})$$

$$3 - m_{1+2} = 0.37$$

$$m_{1+2} = 2.63$$

Exam #1

scientific calculator

graphing calculator

Short Project due November 21 **by 11:00AM**

Project: select a topic from the website list and…

1) Write a two-page summary of the topic and its importance to astronomy
2) Complete a “cover sheet” page including a short abstract and technical description of an observation that you would want to carry out related to this topic.
3) Prepare a short (4-minute) clear presentation explaining the topic and proposed observations
4) Summarize the topic and proposed observations as a conference-quality research poster

Projects will be done in groups of 4; each group member picks ONE of these four things to do.

Short Project due November 21 **by 11:00AM**

Two-page summary:

—explains your topic (audience: peers)

—clarifies its importance to astronomy

—discusses outstanding questions or next steps

—cites *at least* two papers from literature

Graded on: quality of writing, organization, clarity, demonstration of understanding underlying concepts

Short Project due November 21 **by 11:00AM**

Cover sheet:

Name: ______________________________ **DUE:** Nov 21, 2017 (by 11:00AM)

Topic: ____

Abstract (in 3-5 sentences explain your topic and your proposed observations):

Telescope?

Image or spectrum?

When will you take these observations?

How much time do you estimate needing?

Technical Justification (1/2 page justifying your choice of telescope, observation type, time estimate, and what your proposed observations would contribute to the astronomy community's understanding of your topic):

Graded on: quality of writing, clarity, choice of proposed observations, demonstration of understanding underlying concepts

Short Project due November 21 **by 11:00AM**

Presentation:

—Keynote, Powerpoint, PDF, online (Prezi, etc.)

—gives *succinct* summary of topic, its importance, and proposed future work

—should include at least one visual (figure from paper or similar)

—should *not* be read from a script or notes

—four minutes takes *a lot* of planning!

Graded on: organization, timeliness, quality of presentation skills, demonstration of understanding underlying concepts

Short Project due November 21 **by 11:00AM**

Poster:

—Keynote, Powerpoint, PDF; printable as a 36”x44” poster

(but submit electronically! no need to print!)

—gives summary of topic, its importance, and proposed future work (including text summary and representative figures)

—includes reference list and figure captions; should serve as a stand-alone summary

Graded on: organization, clarity, visual presentation, demonstration of understanding underlying concepts

Short ... y 11:00AM

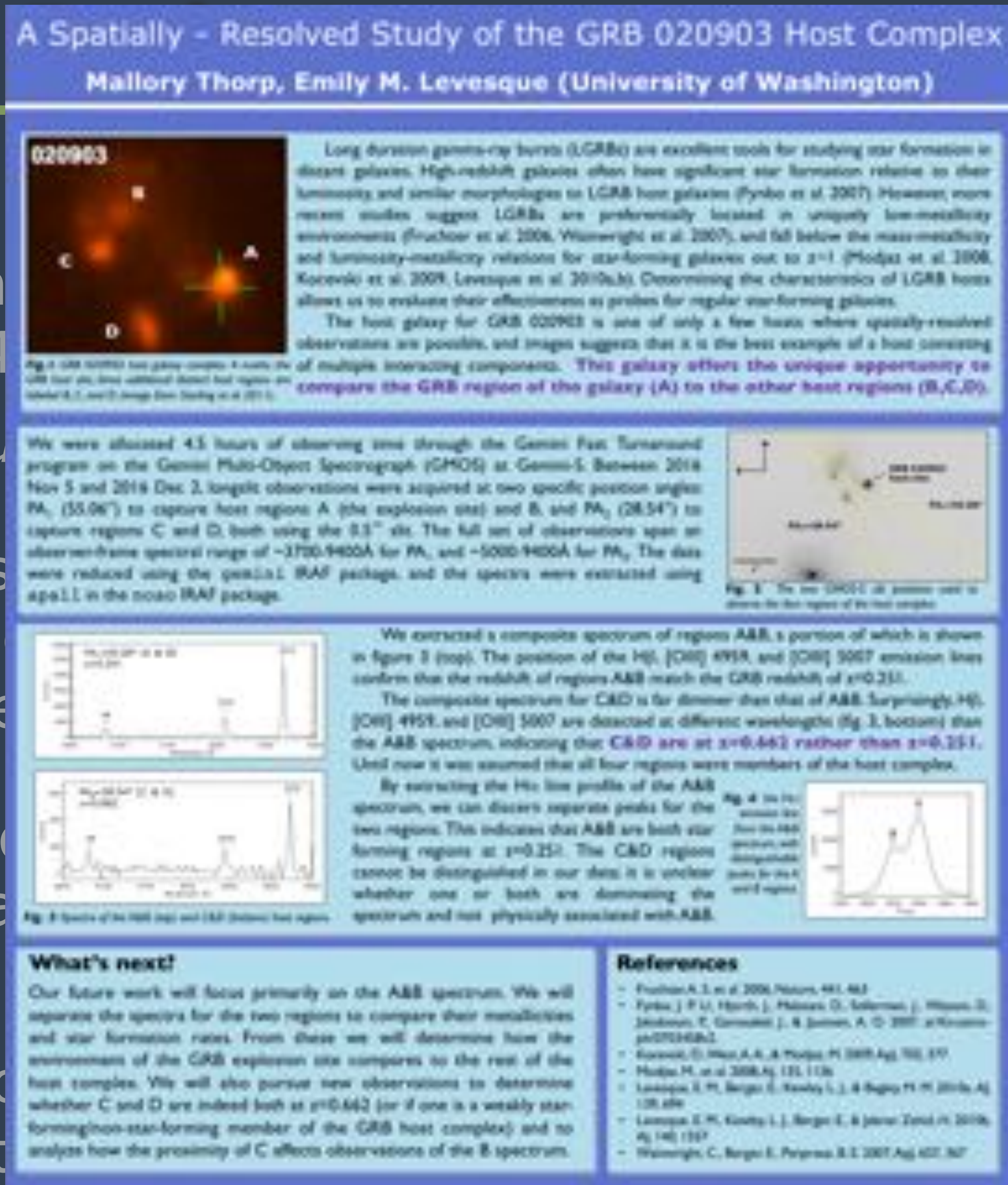
Poster:

—Keyn ... a 36"x44 ...

(but su ... nt!)

—gives ... and propos ... mary and represe ...

—inclu ... ns; should serve a ...



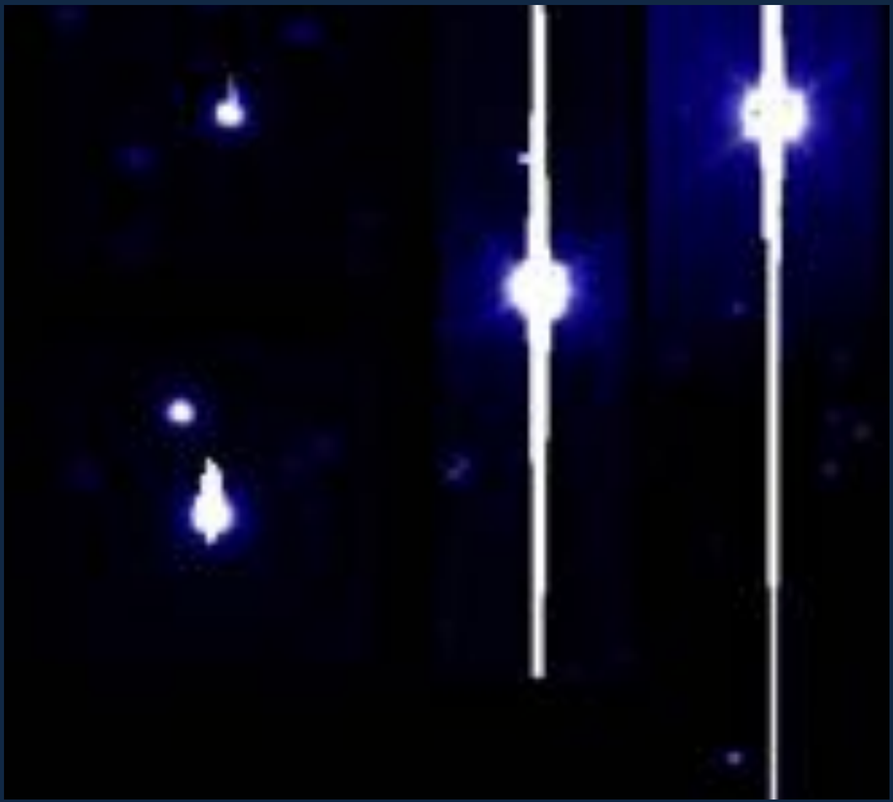
Graded o ... sentation, demonst ... concepts

Short Project due November 21 **by 11:00AM**

Exposure times

We can use an object's brightness to estimate the exposure time that we need…

Too long:



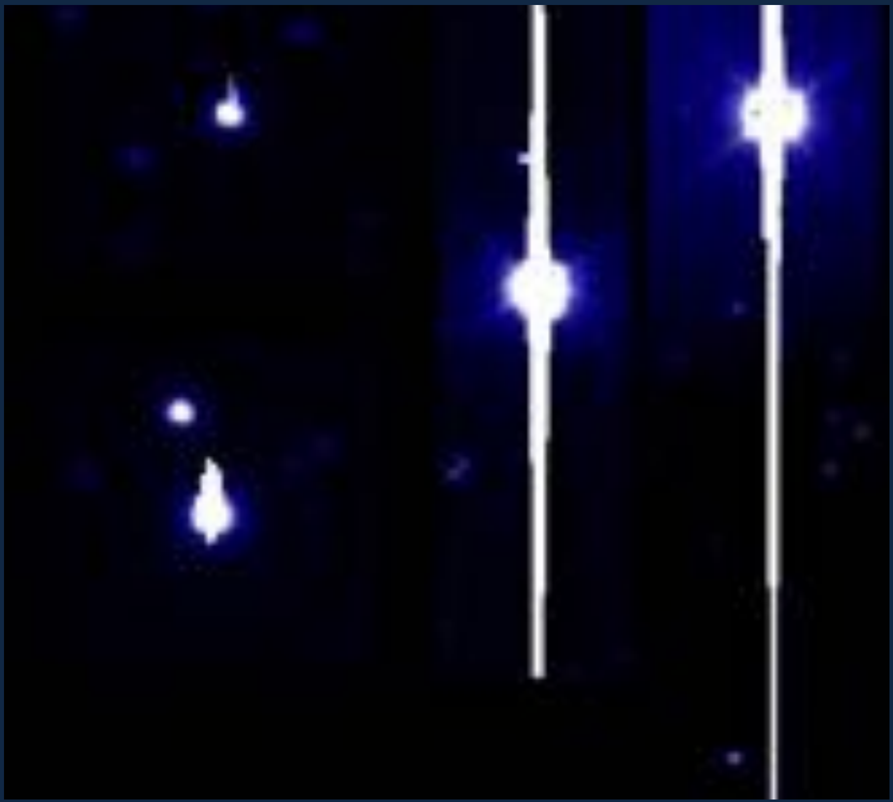
Too short:

Short Project due November 21 **by 11:00AM**

Exposure times

We can use an object's brightness to estimate the exposure time that we need…

Too long:



~~**Too short:**~~ enough!

Short Project due November 21 **by 11:00AM**

Exposure times

To determine how long we expose on something we start with the signal-to-noise ratio:

$$\frac{S}{N} = \frac{F}{\sqrt{F + n_s(B + \sigma^2_{read})}}$$

F = flux from source, B = flux from background,
n_s = number density of source counts, σ^2_{read} = readout noise

Short Project due November 21 **by 11:00AM**

Exposure times

To determine how long we expose on something we start with the signal-to-noise ratio:

$$\frac{S}{N} = \frac{F}{\sqrt{F+n_s(B+\sigma^2_{read})}}$$

If the source flux dominates:

$$\frac{S}{N} = \sqrt{F}$$

F = flux from source, B = flux from background,
n_s = number density of source counts, σ^2_{read} = readout noise

Short Project due November 21 **by 11:00AM**

Exposure times

To determine how long we expose on something we start with the signal-to-noise ratio:

$$\frac{S}{N} = \frac{F}{\sqrt{F + n_s(B + \sigma^2_{read})}}$$

If background flux dominates:

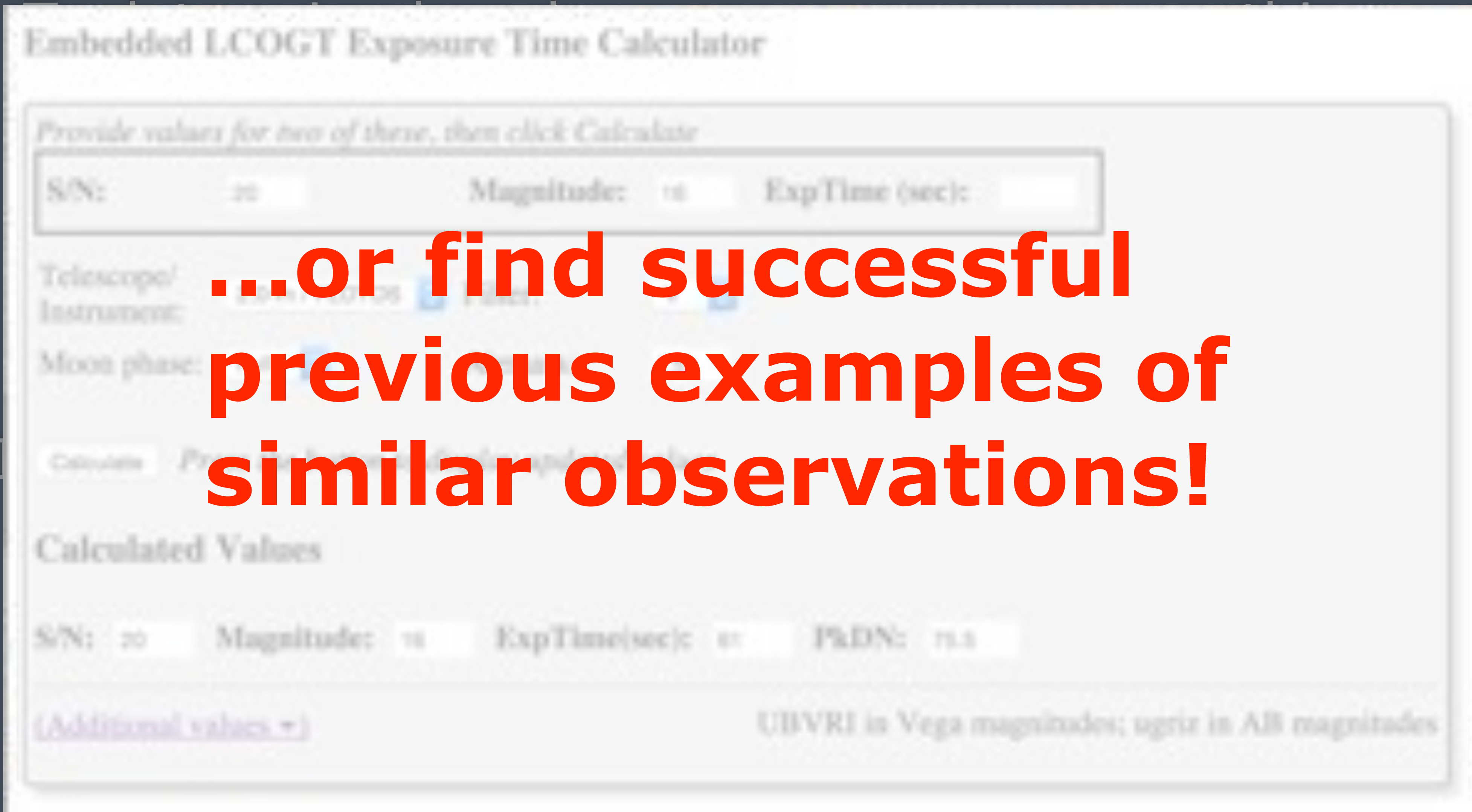
$$\frac{S}{N} = \frac{F}{\sqrt{n_s B}}$$

F = flux from source, B = flux from background,
n_s = number density of source counts, σ^2_{read} = readout noise

Short Project due November 21 **by 11:00AM**

Exposure times

In reality…



…or find successful previous examples of similar observations!

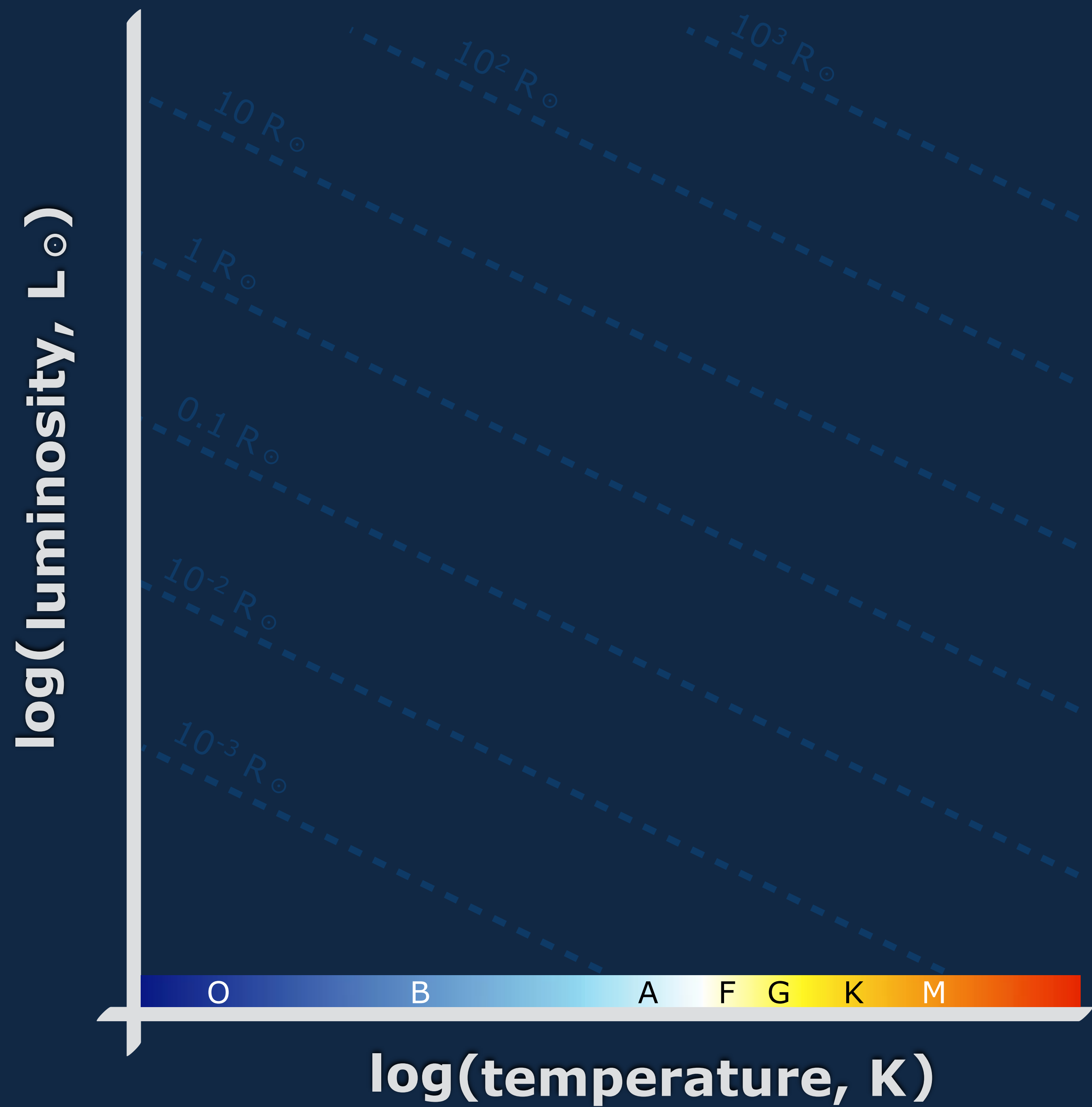
F = flux from source, B = flux from background,

n_s = number density of source counts, σ^2_{read} = readout noise

Properties of Stars

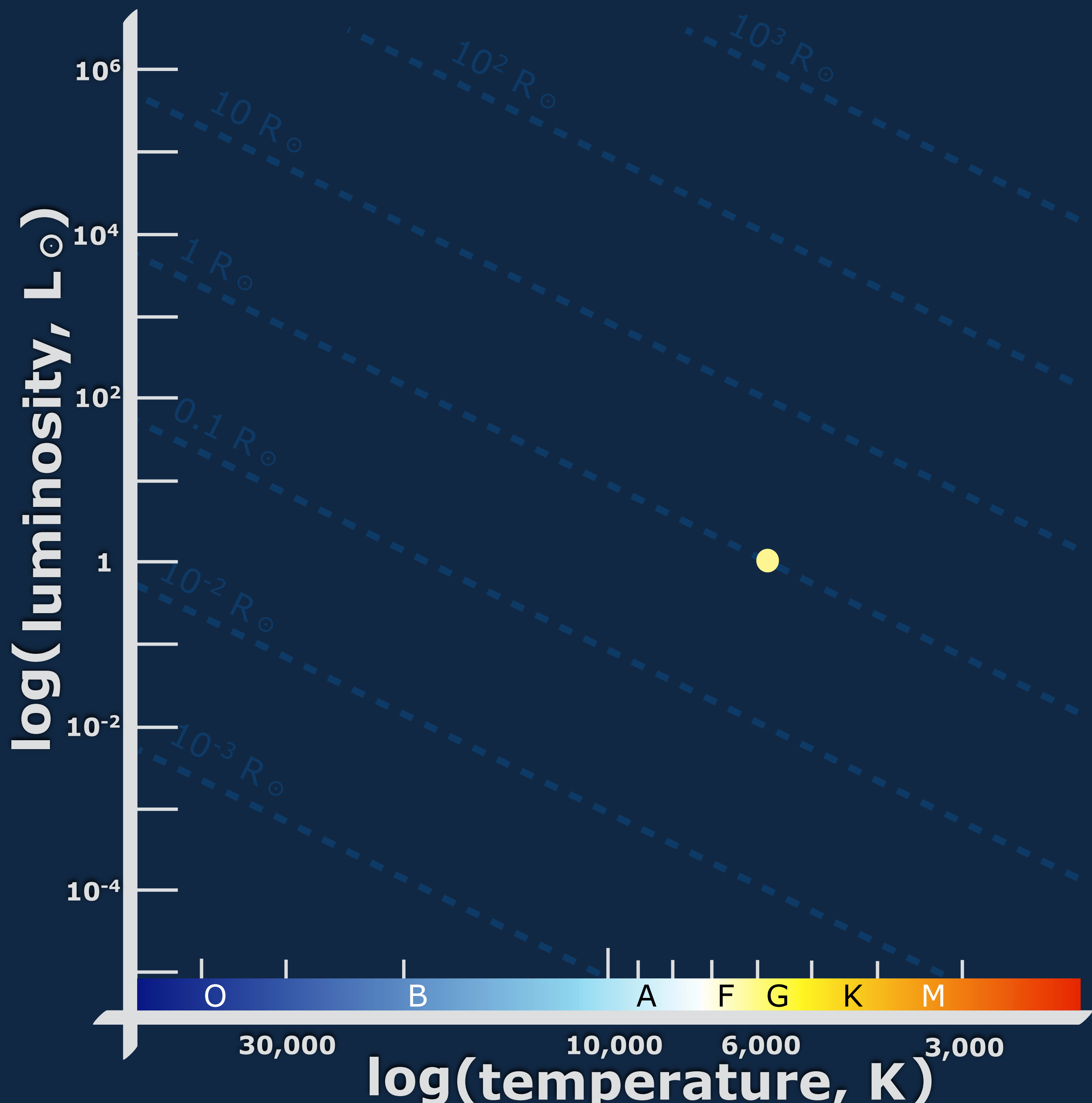
1) ~~Distance – parallax, Cepheids~~
2) ~~Velocity – proper motion, radial velocity~~
3) Brightness - magnitudes, luminosity
4) Temperature - effective temp (usually)
5) Mass - luminosity, binaries
6) Radius - lunar, interferometry, binaries, L & T

The Hertzsprung-Russell Diagram

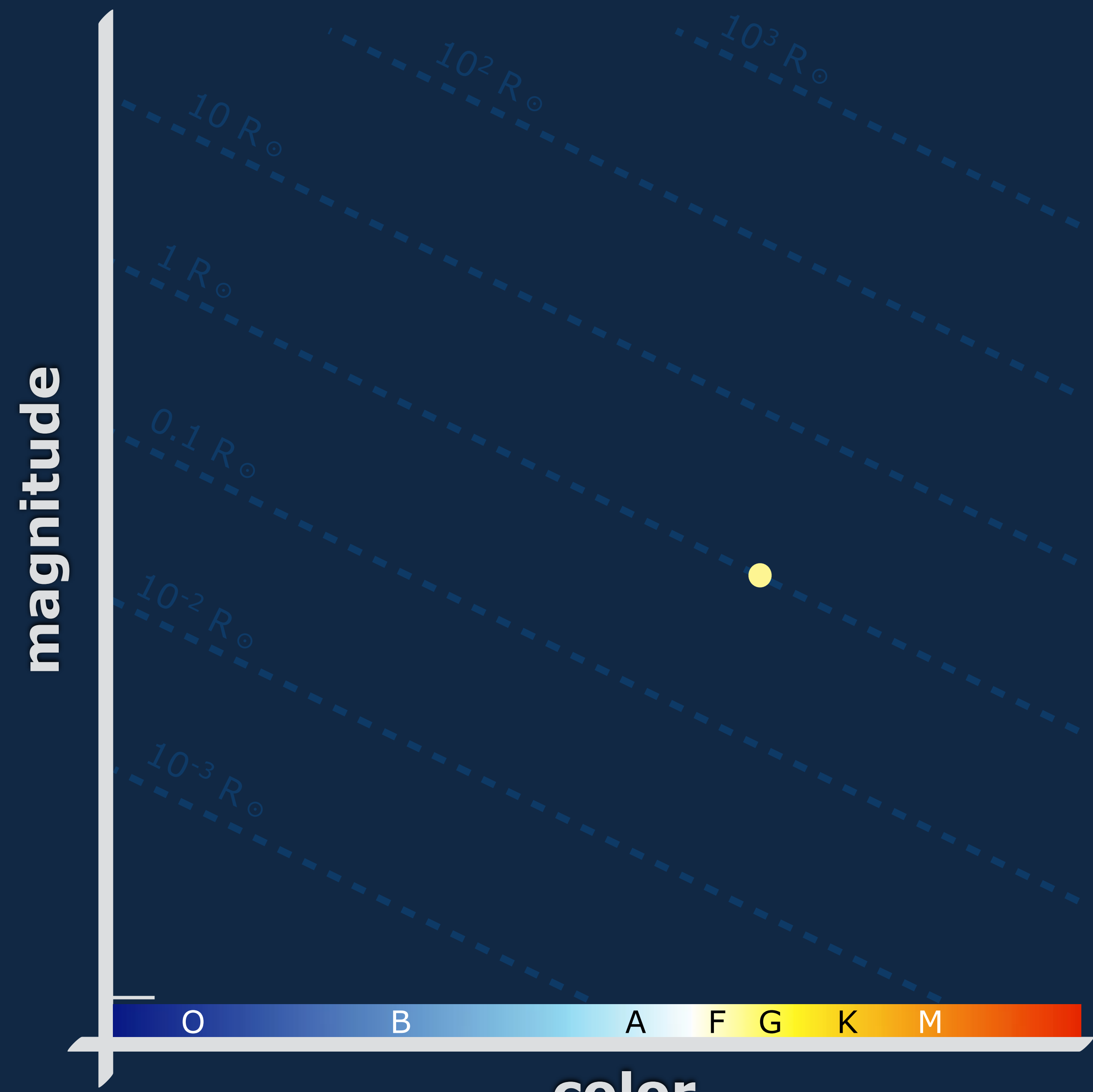


lines of constant radius

The Hertzsprung-Russell Diagram



The Color-Magnitude Diagram



Stellar Structure

Basic Stellar Structure Equations

1) Equation of State:

$$PV = nRT$$

$$P \propto T,\ P \propto 1/V \sim \rho,\ P \propto \rho T \text{ so}$$

$$P = (k/\mu m_H)\rho T$$

where $1/\mu = 2X + (3/4)Y + (1/2)Z$

with radiative P: $P = (k/\mu m_H)\rho T + (a/3)T^4$

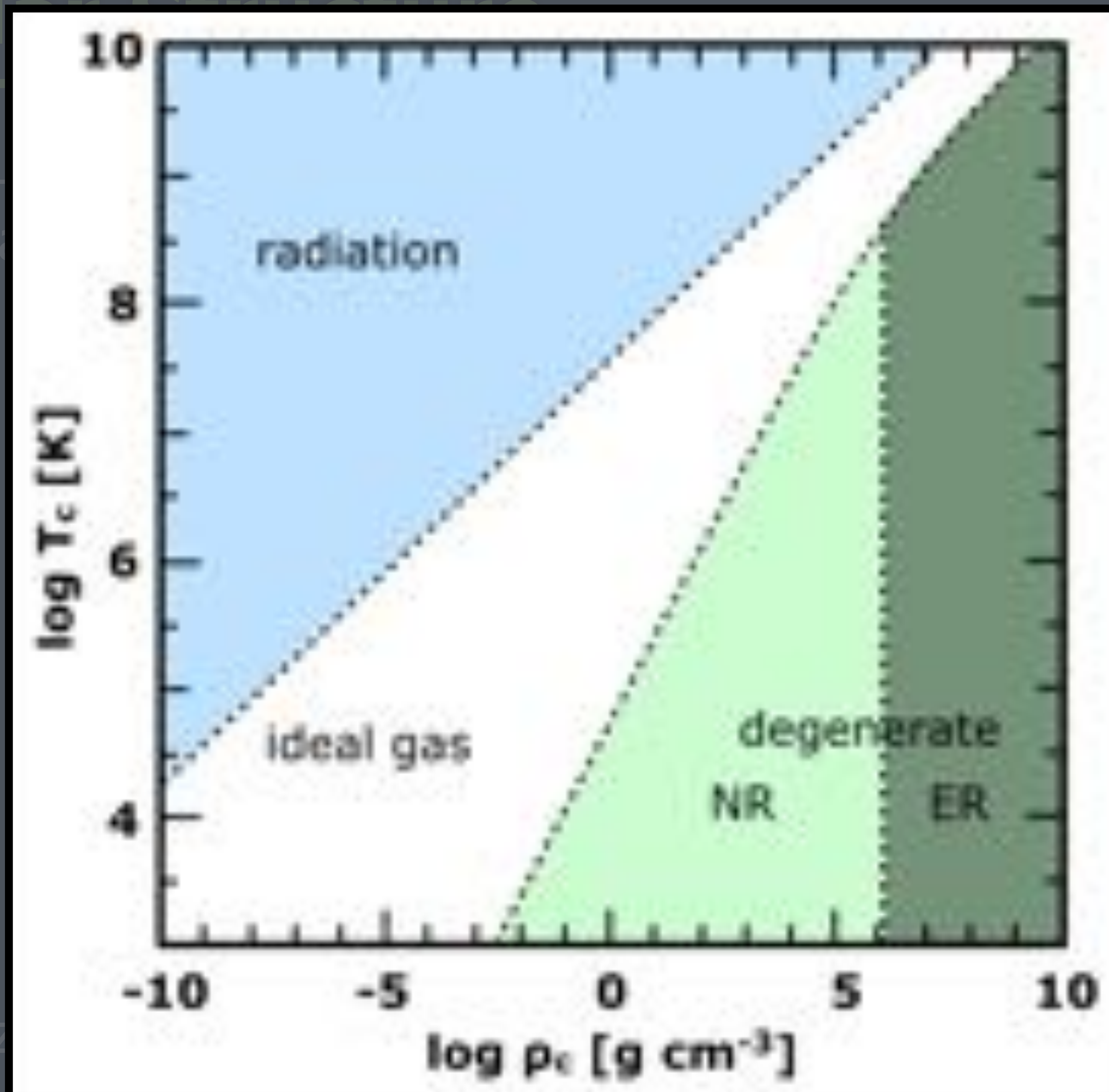
k=Boltzmann constant, $a = (8\pi^5 k^4)/(15h^3c^3)$

X=H mass fraction, Y=He mass fraction, Z=metals

Stell

Basic

1) Equa



k=Boltz

X=H mass fraction, Y=He mass fraction, Z=metals

Stellar Structure

Basic Stellar Structure Equations

1) Equation of State: $P = (k/\mu m_H)\rho T + (a/3)T^4$

2) Hydrostatic Equilibrium:

$$\frac{\Delta P(r)}{\Delta r} = \frac{-GM(r)\rho(r)}{r^2}$$

Center of star: r=0; surface of star: r=R (stellar radius)

Stellar Structure

Basic Stellar Structure Equations

1) Equation of State: $P = (k/\mu m_H)\rho T + (a/3)T^4$

2) Hydrostatic Equilibrium: $$\frac{\Delta P(r)}{\Delta r} = \frac{-GM(r)\rho(r)}{r^2}$$

3) Mass continuity:

$$\frac{\Delta M(r)}{\Delta r} = 4\pi r^2 \rho(r)$$

Center of star: $r=0$; surface of star: $r=R$ (stellar radius)

Stellar Structure

Basic Stellar Structure Equations

1) Equation of State: $P = (k/\mu m_H)\rho T + (a/3)T^4$

2) Hydrostatic Equilibrium: $\dfrac{\Delta P(r)}{\Delta r} = \dfrac{-GM(r)\rho(r)}{r^2}$

3) Mass continuity: $\dfrac{\Delta M(r)}{\Delta r} = 4\pi r^2 \rho(r)$

4) Luminosity gradient (in TE):

$$\frac{\Delta L(r)}{\Delta r} = 4\pi r^2 \rho(r)(\varepsilon - \varepsilon_\nu)$$

$\varepsilon(\rho, T, \text{comp})$, ε_ν = neutrino energy

Center of star: $r=0$; surface of star: $r=R$ (stellar radius)

Stellar Structure

Basic Stellar Structure Equations

1) Equation of State: $P = (k/\mu m_H)\rho T + (a/3)T^4$

2) Hydrostatic Equilibrium: $\dfrac{\Delta P(r)}{\Delta r} = \dfrac{-GM(r)\rho(r)}{r^2}$

3) Mass continuity: $\dfrac{\Delta M(r)}{\Delta r} = 4\pi r^2 \rho(r)$

4) Luminosity gradient (in TE): $\dfrac{\Delta L(r)}{\Delta r} = 4\pi r^2 \rho(r)(\varepsilon - \varepsilon_\nu)$

5) Temperature gradient:

$\kappa \propto \rho T^{-3.5}$ = "opacity"

$a = (8\pi^5 k^4)/(15h^3c^3)$

$$\frac{\Delta T(r)}{\Delta r} = \frac{-3\kappa\rho(r)L(r)}{16\pi a c r^2 T(r)^3}$$

Center of star: r=0; surface of star: r=R (stellar radius)

Stellar Structure

Basic Stellar Structure Equations

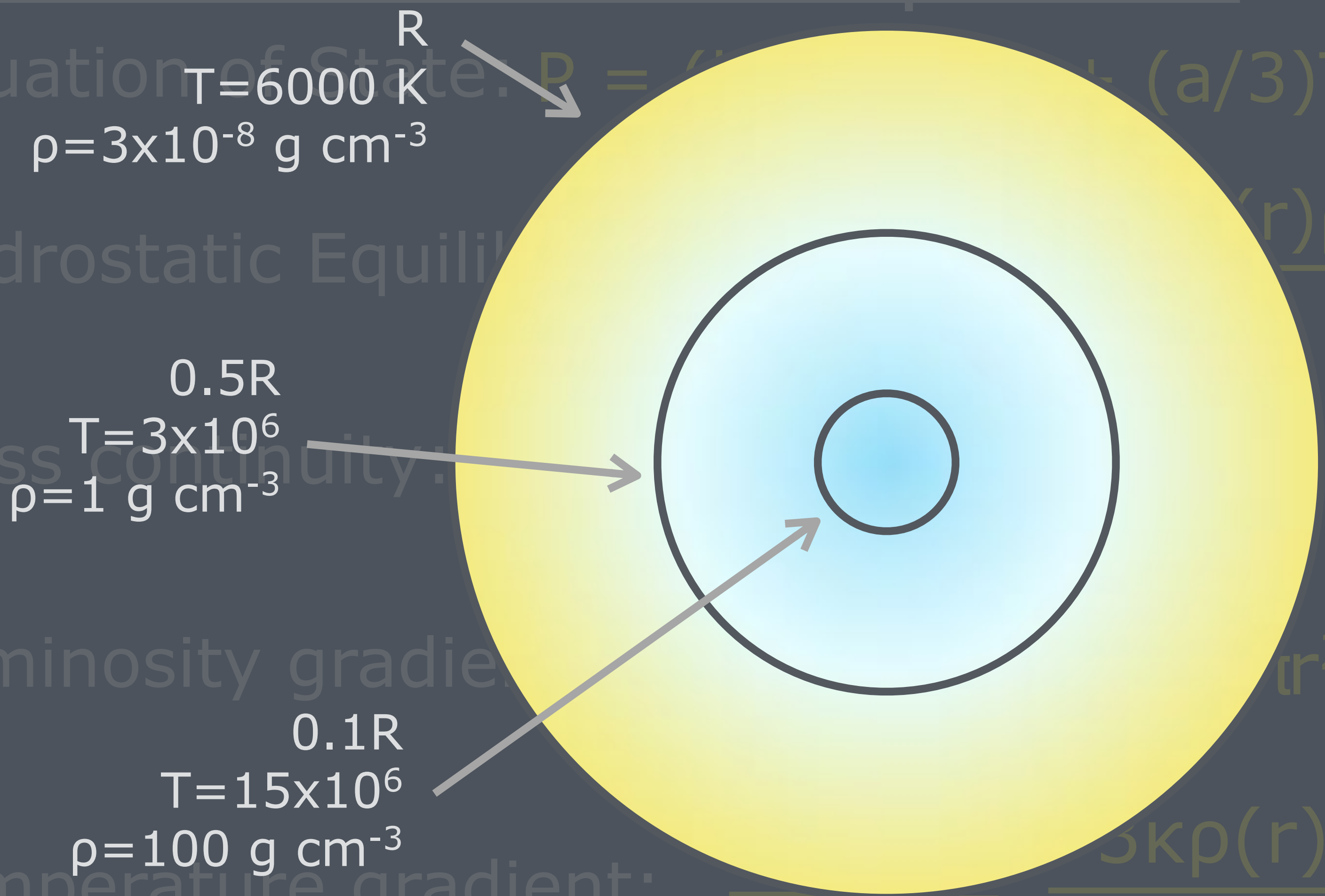
1) Equation of State: $P = \ldots + (a/3)T^4$

2) Hydrostatic Equilibrium: $\ldots (r)\rho(r)$

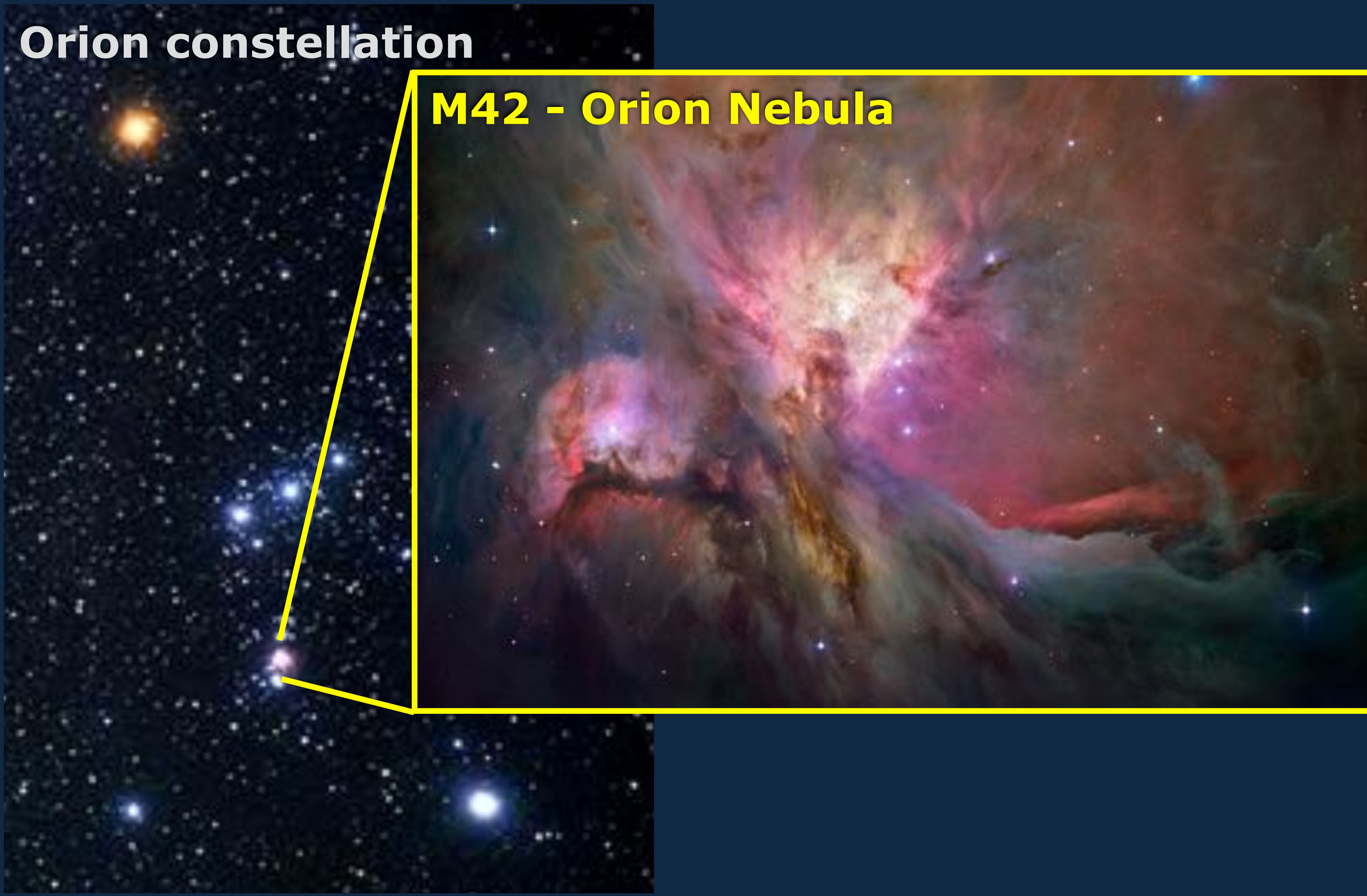
3) Mass continuity:

4) Luminosity gradient: $\ldots r^2\rho(r)(\varepsilon-\varepsilon_\nu)$

5) Temperature gradient: $\dfrac{\ldots}{\Delta r} = \dfrac{3\kappa\rho(r)L(r)}{16\pi a c r^2 T(r)^3}$



Star Formation



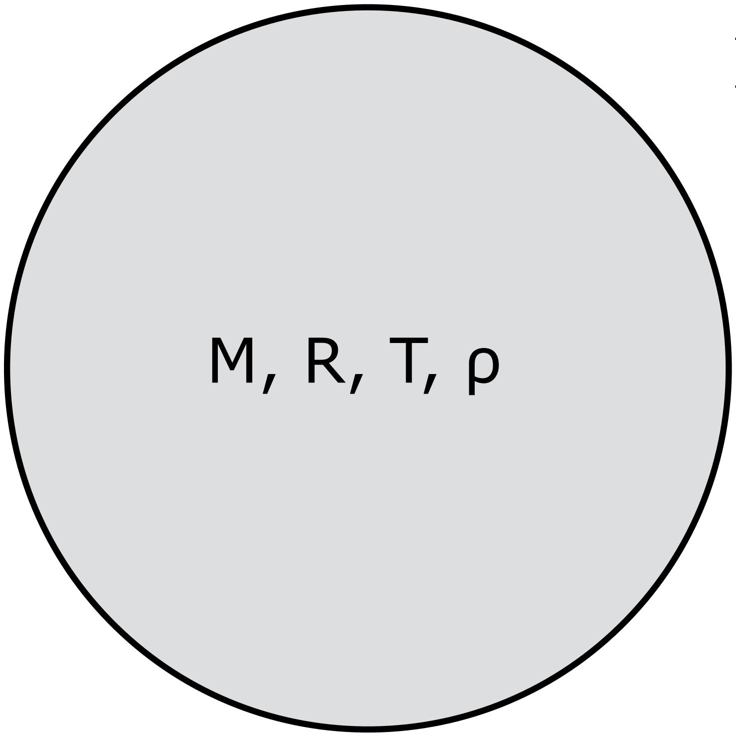
Star Formation

Consider a spherical homogenous cloud:

$$\mathrm{E}_{\mathrm{kin}} = -\frac{1}{2}\mathrm{E}_{\mathrm{pot}}$$ ← **virial theorem**

Star Formation

Consider a spherical homogenous cloud:



$$E_{\mathrm{kin}} = -\frac{1}{2}E_{\mathrm{pot}}$$ ←**virial theorem**

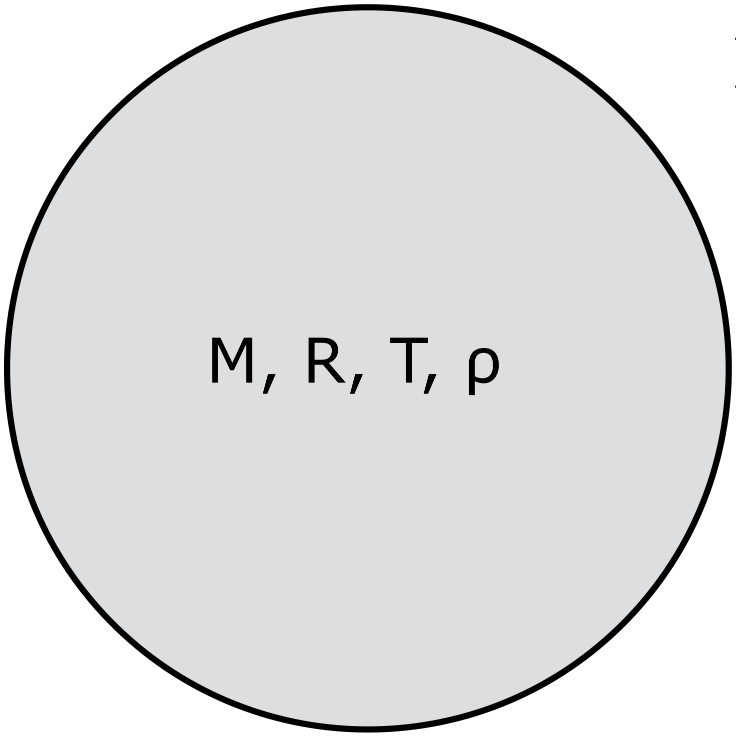
$E_{kin}=(3/2)NkT$, $N=M/\mu m_H$

$E_{pot}=(3/5)(GM^2/R)$, $R=(3M/4\pi\rho)^{1/3}$

What condition do we need to meet for collapse?

Star Formation

Consider a spherical homogenous cloud:



$$E_{kin} = -\frac{1}{2} E_{pot}$$ **←virial theorem**

$E_{kin} = (3/2)NkT$, $N = M/\mu m_H$

$E_{pot} = (3/5)(GM^2/R)$, $R = (3M/4\pi\rho)^{1/3}$

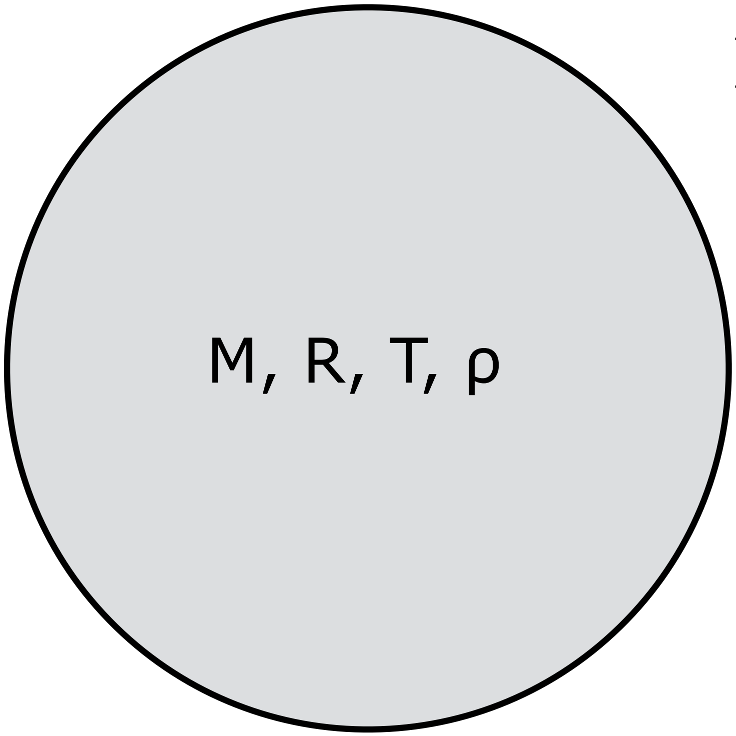
What condition do we need to meet for collapse?

$$E_{kin} < -\frac{1}{2} E_{pot}$$

$$\boxed{M > M_J \equiv \frac{5kTR}{G\mu m_H}}$$ **Jeans mass**

Star Formation

Consider a spherical homogenous cloud:



$$\mathrm{E}_{\mathrm{kin}} = -\frac{1}{2}\mathrm{E}_{\mathrm{pot}}$$ **←virial theorem**

$E_{kin}=(3/2)NkT$, $N=M/\mu m_H$

$E_{pot}=(3/5)(GM^2/R)$, $R=(3M/4\pi\rho)^{1/3}$

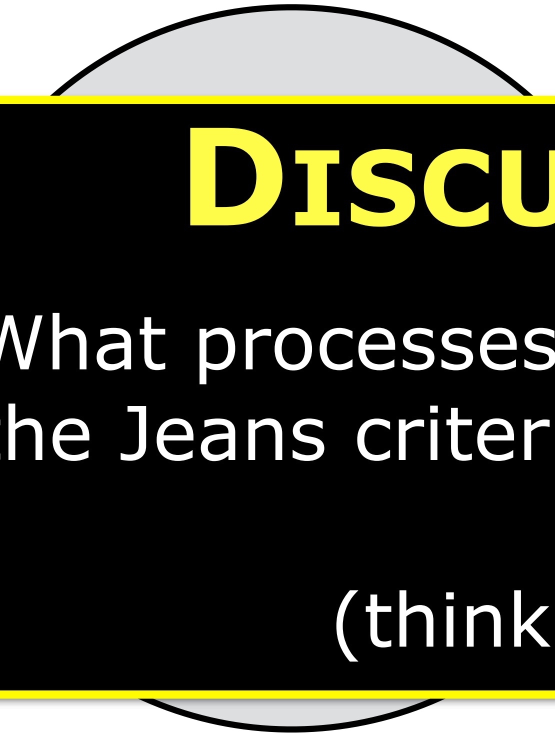
What condition do we need to meet for collapse?

$$\boxed{M > M_J \equiv \frac{5kTR}{G\mu m_H}}$$ **Jeans mass**

$$\left(R < R_J \equiv \frac{G\mu m_H M}{5kT}\right)$$

Star Formation

Consider a spherical homogenous cloud:



$$\mathrm{E}_{\mathrm{kin}} = -\frac{1}{2}\mathrm{E}_{\mathrm{pot}}$$ ←**virial theorem**

DISCUSSION QUESTION

What processes might cause our cloud to exceed the Jeans criteria?

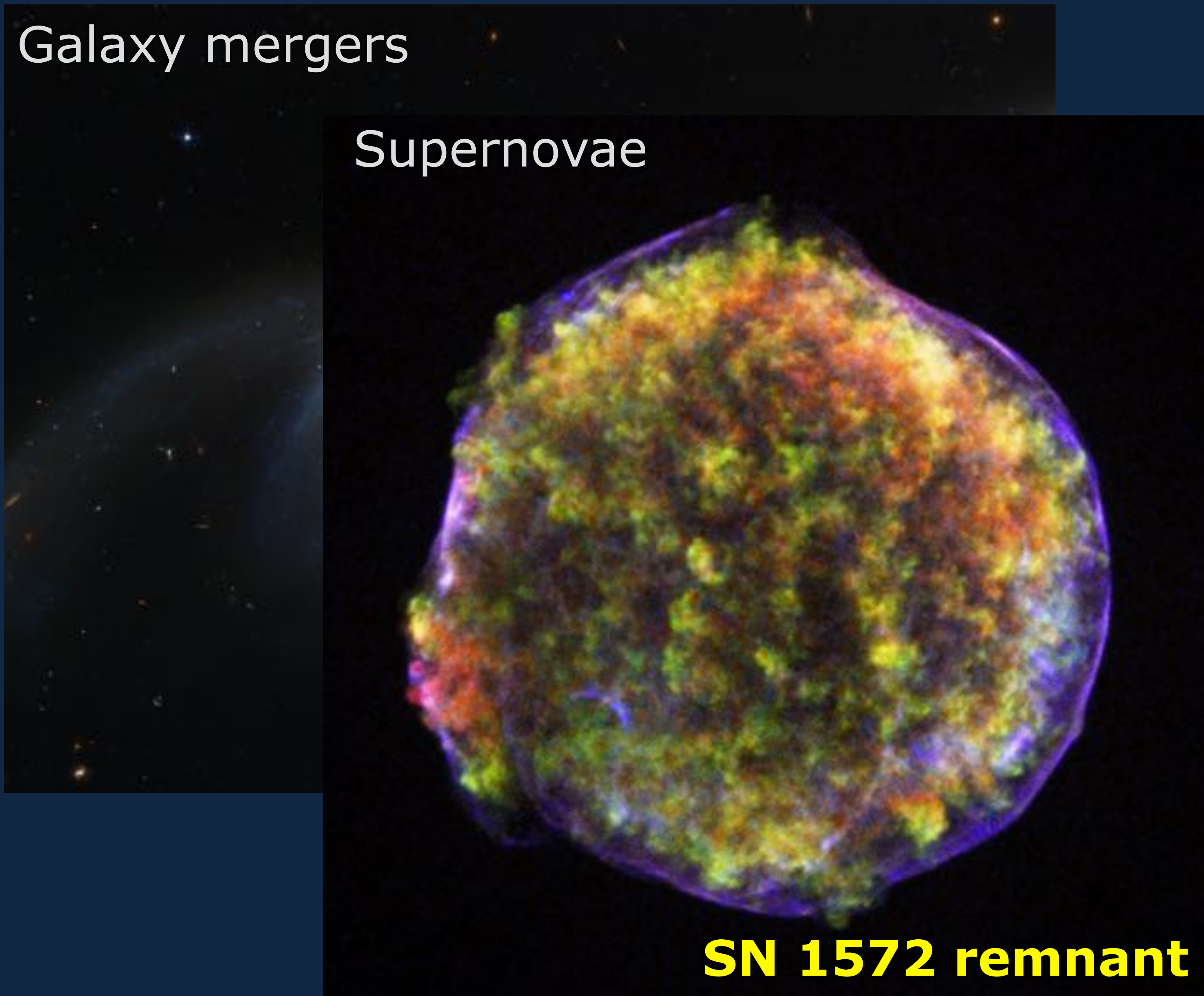
(think, discuss, then answer)

$$\boxed{M > M_J \equiv \frac{5kTR}{G\mu m_H}}$$ **Jeans mass**

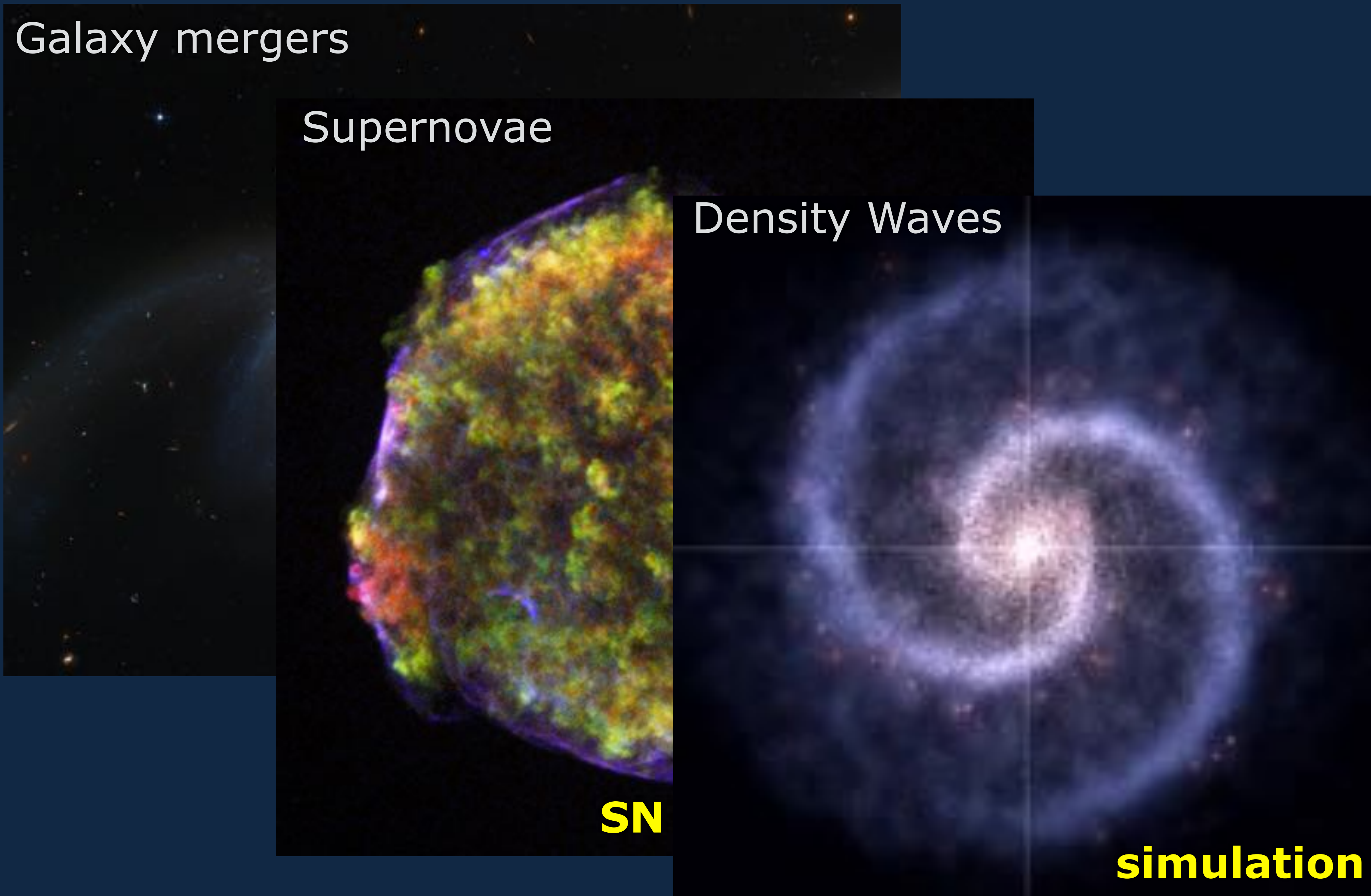
$$\left(R < R_J \equiv \frac{G\mu m_H M}{5kT} \right)$$

Star Formation

Star Formation



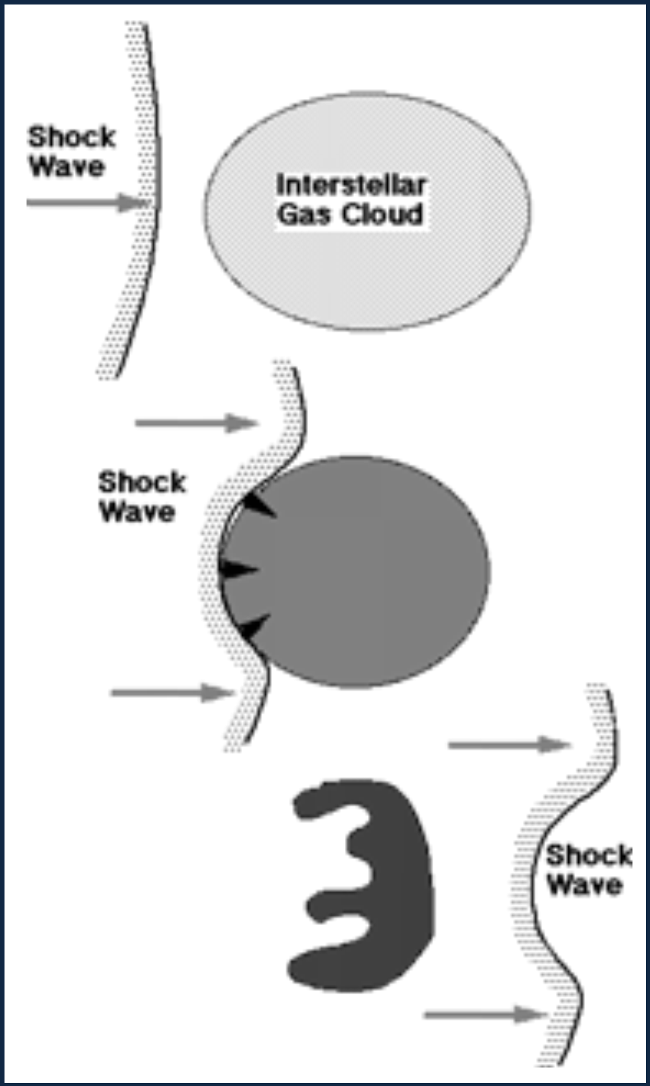
Star Formation

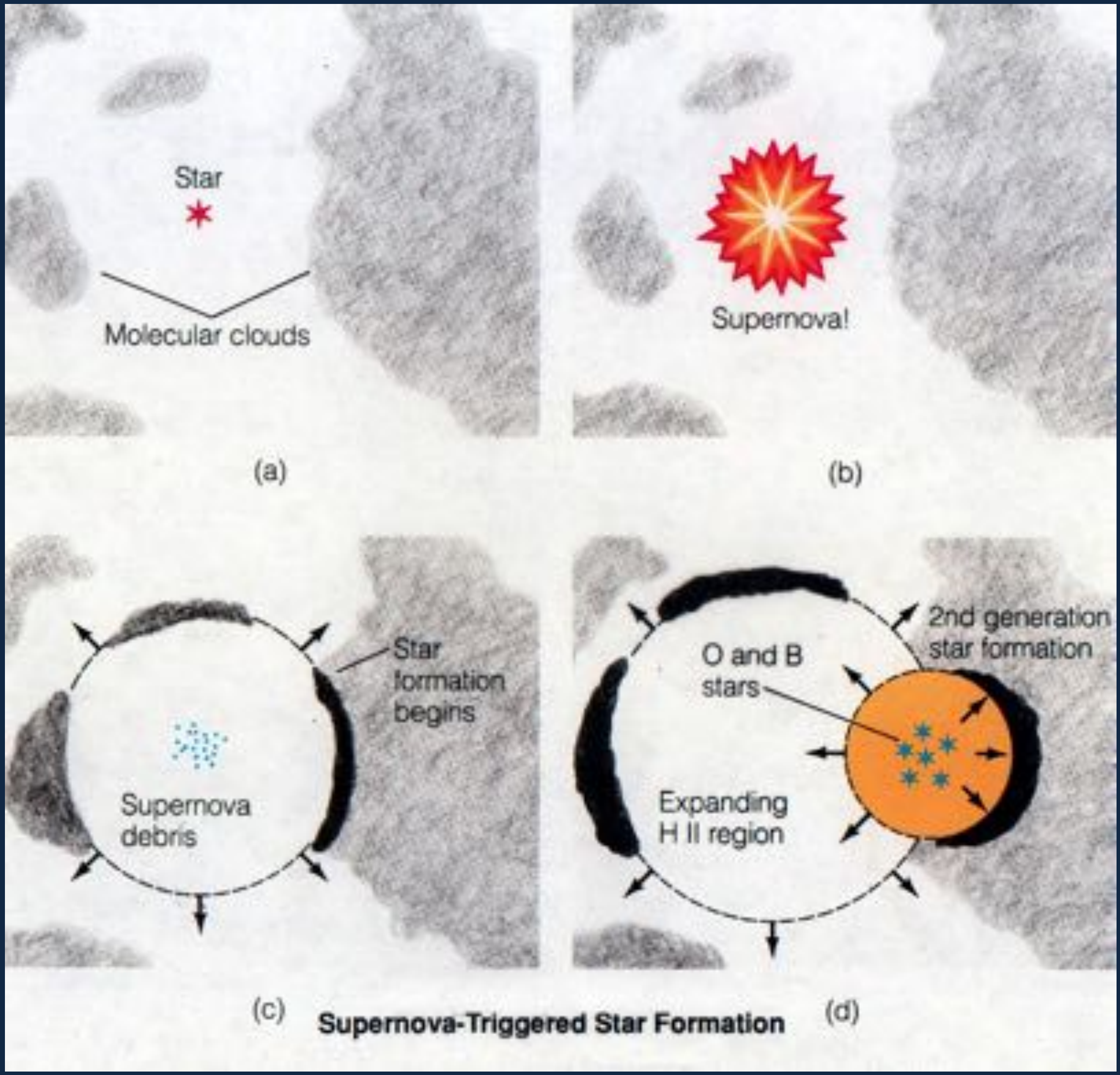


Star Formation

Birth Sequence

- trigger kicks off process in an interstellar gas cloud





Star Formation

Birth Sequence

- trigger kicks off process in an interstellar gas cloud
- cloud fragments and collapses [M_J and R_J…]
- early collapse is isothermal; E radiated away
- interior becomes adiabatic; E trapped so T rises
- protostellar core forms (~5AU) w/ free-falling gas above
- dust vaporizes as T increases

Star Formation

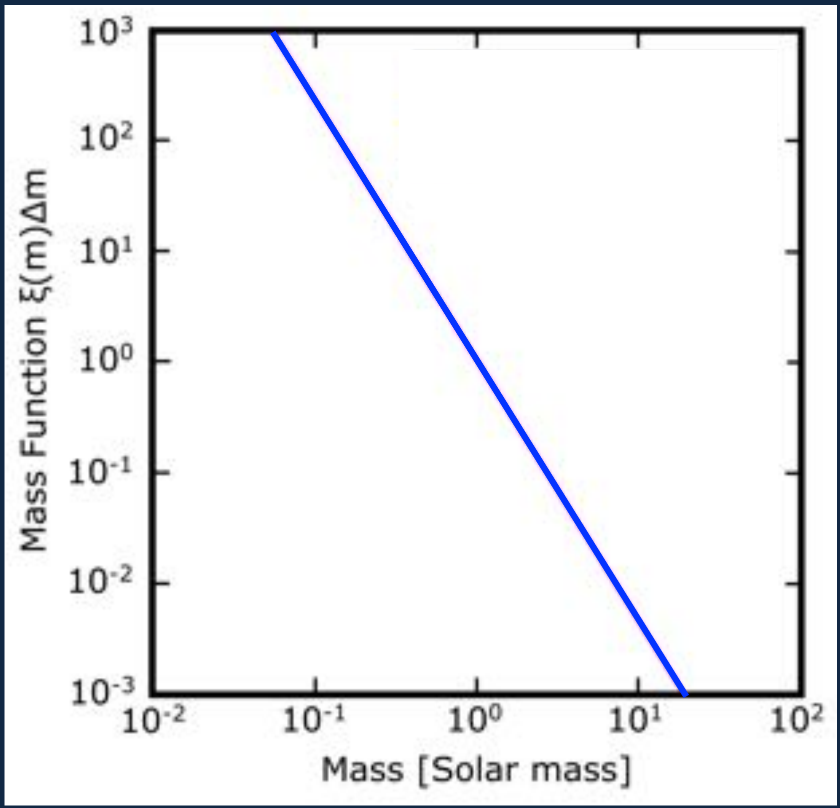
Unfortunately, no good quantitative theory to predict star formation rate or stellar mass distribution!

IMF = Initial Mass Function

N(m)dm = # stars in mass range m to m+dm

$N(m)dm \propto (m/M_{sun})^{-\alpha}$

α = 2.35 (Salpeter IMF)



Star Formation

Unfortunately, no good quantitative theory to predict star formation rate or stellar mass distribution!

IMF = Initial Mass Function

$N(m)dm$ = # stars in mass range m to m+dm

$N(m)dm \propto (m/M_{sun})^{-\alpha}$

$\alpha = 2.35$ (Salpeter IMF)

Is it universal?