Review for Unit #2

Thanks to:

Ben Brown, Cristin Noonan,
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Sharaine Conner, Stacy Schmidgall

How to study?

1) Go over the homework, particularly problems that you missed, until you understand each problem (not just know the right answer). Do this by talking with a friend, going to astronomy tutorial, or going to office hours.
2) Read the lecture notes.
3) Read the textbook. Use the questions at the end to quiz yourself.

Quick questions

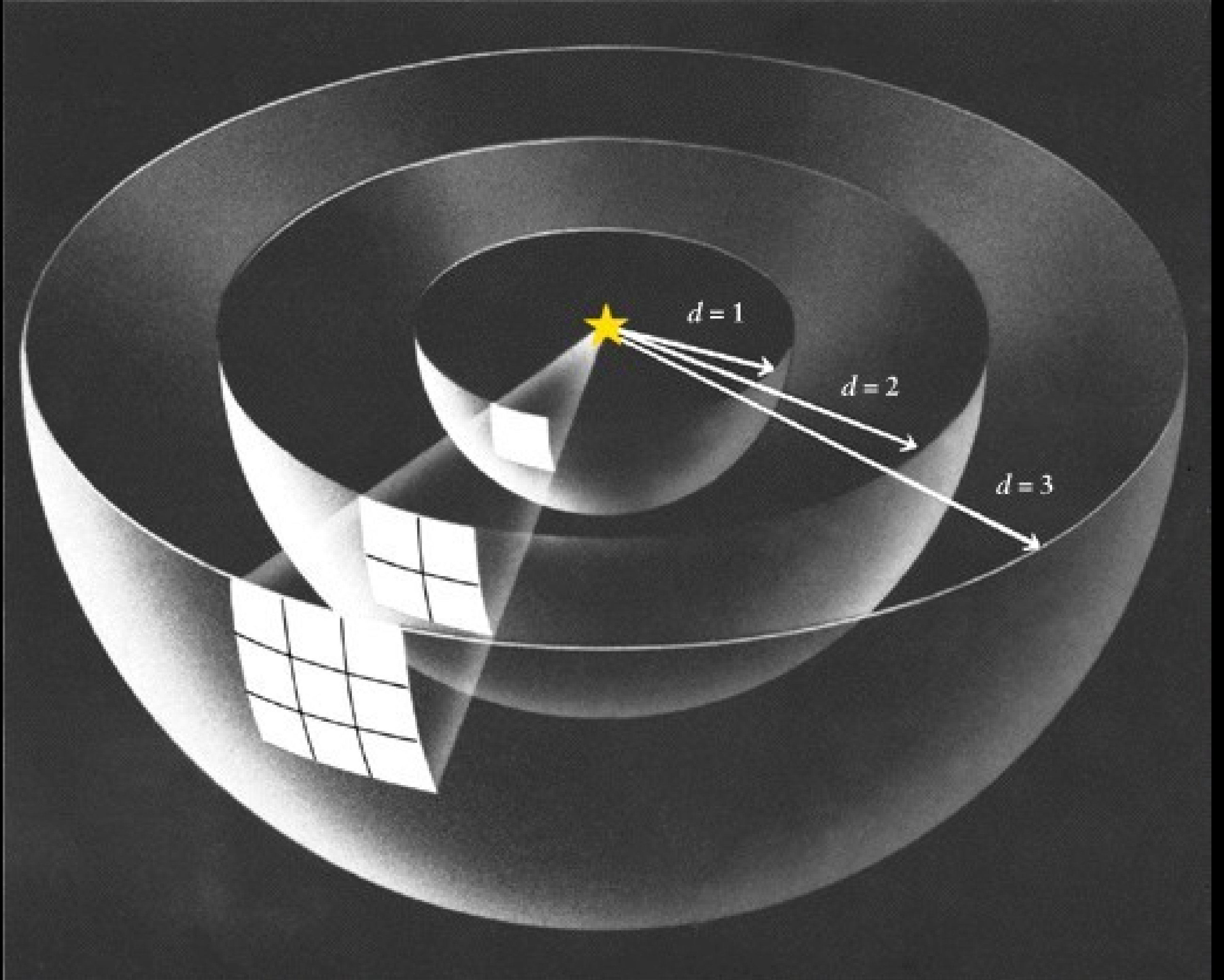
- Do we need to know the parts of the Sun? **Yes**
- Do we need to know fusion and fission? **Yes**
- Do we need to know main sequence evolution (main sequence, red giant, helium flash, planetary nebula, white dwarf)? **Yes**
- Will there be questions about the human eye? **No**
- Will there be questions about magnitudes? **No**
- Do we need to know equations in the book that are not in the lectures? **You need to know the equations that were needed for the homework.**

Quick Answers

- The interstellar medium is the gas and dust between clouds. Nebulae and molecular clouds are parts of the interstellar medium.
- Fusion stops at Iron because Iron has the lowest ratio of mass divided by number of protons plus neutrons. If you try to fuse anything with Iron, you have to put in energy.
- The mass of a star determines what elements can undergo fusion inside the star. A solar mass star can fuse He into C and O, but nothing heavier. A 10 solar mass star can fuse elements all the way up to Iron because it has a higher core temperature and pressure.

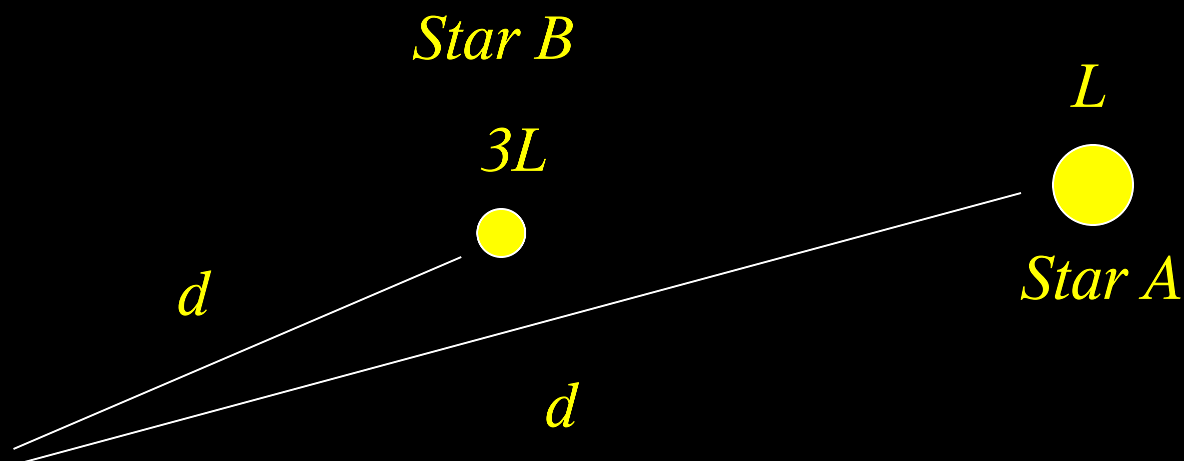
Quick Answers

- Blackbodies make a continuous spectrum
- Gas emit or absorb spectral lines
  - Clouds emit lines if hotter than a background star or illuminated by UV radiation
  - Clouds absorb lines if cooler than a background star



d = 1
d = 2
d = 3

Distance-Luminosity relation: Which star appears brighter to the observer?



Star B is
A) the same brightness as star A
B) 3 times brighter than star A
C) 9 times brighter than star A
D) 1/3 as bright as star A
E) 1/9 as bright as star A

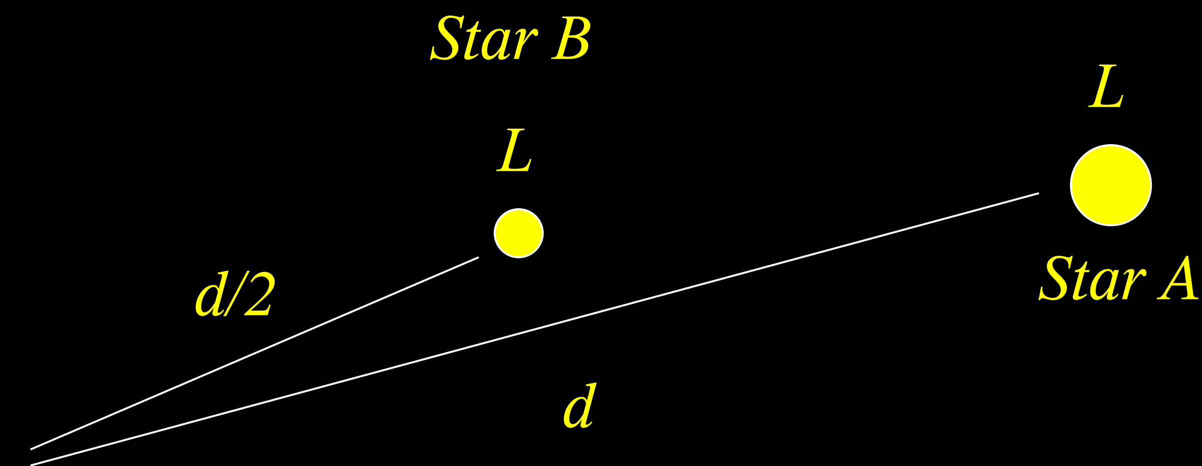
Flux and luminosity

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{\text{Luminosity}_B}{\text{Luminosity}_A}\left(\frac{\text{Distance}_B}{\text{Distance}_A}\right)^{-2}$$

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \frac{3}{1} \qquad \frac{\text{Distance}_B}{\text{Distance}_A} = \frac{1}{1}$$

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{3}{1}\left(\frac{1}{1}\right)^{-2} = 3 \times 1 = 3$$

Distance-Luminosity relation: Which star appears brighter to the observer?



Star B is

A) the same brightness as star A

B) 2 times brighter than star A

C) 4 times brighter than star A

D) 1/2 as bright as star A

E) 1/4 as bright as star A

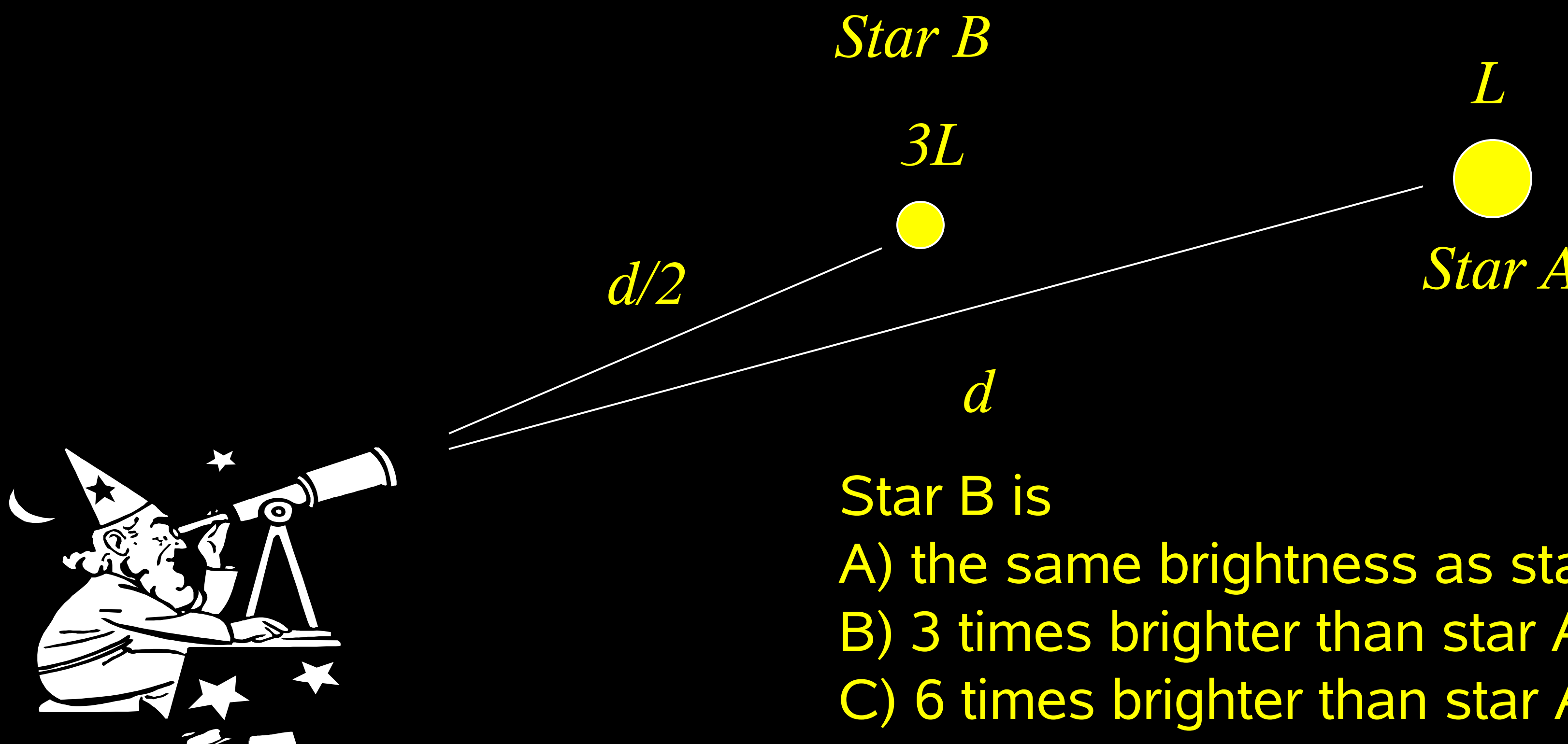
Flux and luminosity

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{\text{Luminosity}_B}{\text{Luminosity}_A} \left(\frac{\text{Distance}_B}{\text{Distance}_A} \right)^{-2}$$

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \frac{1}{1} \qquad \frac{\text{Distance}_B}{\text{Distance}_A} = \frac{1}{2}$$

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{1}{1} \left(\frac{1}{2} \right)^{-2} = 1 \times 4 = 4$$

Distance-Luminosity relation: Which star appears brighter to the observer?



Star B is

A) the same brightness as star A

B) 3 times brighter than star A

C) 6 times brighter than star A

D) 9 times brighter than star A

E) 12 times brighter than star A

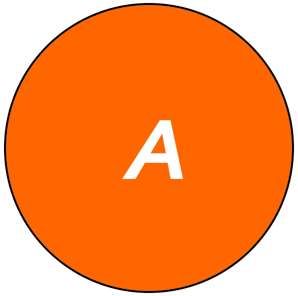
Flux and luminosity

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{\text{Luminosity}_B}{\text{Luminosity}_A}\left(\frac{\text{Distance}_B}{\text{Distance}_A}\right)^{-2}$$

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \frac{3}{1} \qquad \frac{\text{Distance}_B}{\text{Distance}_A} = \frac{1}{2}$$

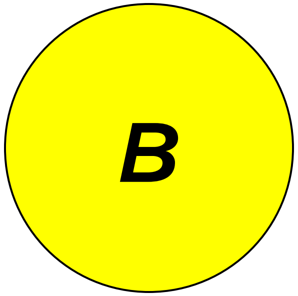
$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{3}{1}\left(\frac{1}{2}\right)^{-2} = 3 \times 4 = 12$$

Luminosity versus radius and temperature



$R = R_{Sun}$

$T = T_{Sun}$



$R = R_{Sun}$

$T = 3T_{Sun}$

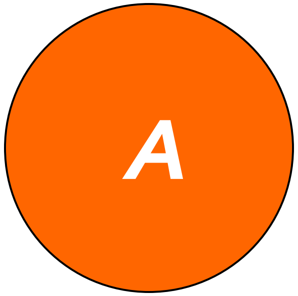
Which star is more luminous?

Luminosity Law

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \left(\frac{\text{Radius}_B}{\text{Radius}_A}\right)^{٢} \left(\frac{\text{Temperature}_B}{\text{Temperature}_A}\right)^{٤}$$

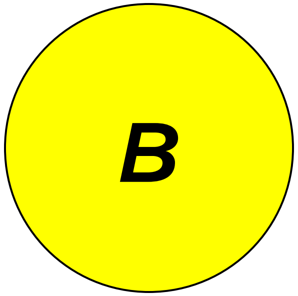
If star A is 3 times as hot as star B, and the same radius, then it will be $3^4 = 3 \times 3 \times 3 \times 3 =$ 81 times as luminous.

Luminosity versus radius and temperature



$R = 4R_{Sun}$

$T = T_{Sun}$



$R = R_{Sun}$

$T = 2T_{Sun}$

Which star is more luminous?

A = A more luminous

B = B more luminous

C = same luminosity

Luminosity Law

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \left(\frac{\text{Radius}_B}{\text{Radius}_A}\right)^2 \left(\frac{\text{Temperature}_B}{\text{Temperature}_A}\right)^4$$

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \left(\frac{1}{4}\right)^2 \left(\frac{2}{1}\right)^4 = \frac{1}{16}\frac{16}{1} = 1$$

The most massive star on the main sequence in a star cluster has a mass of 5 solar masses. Approximately how old is the cluster?

How long does a 5 solar mass star live on the main sequence?

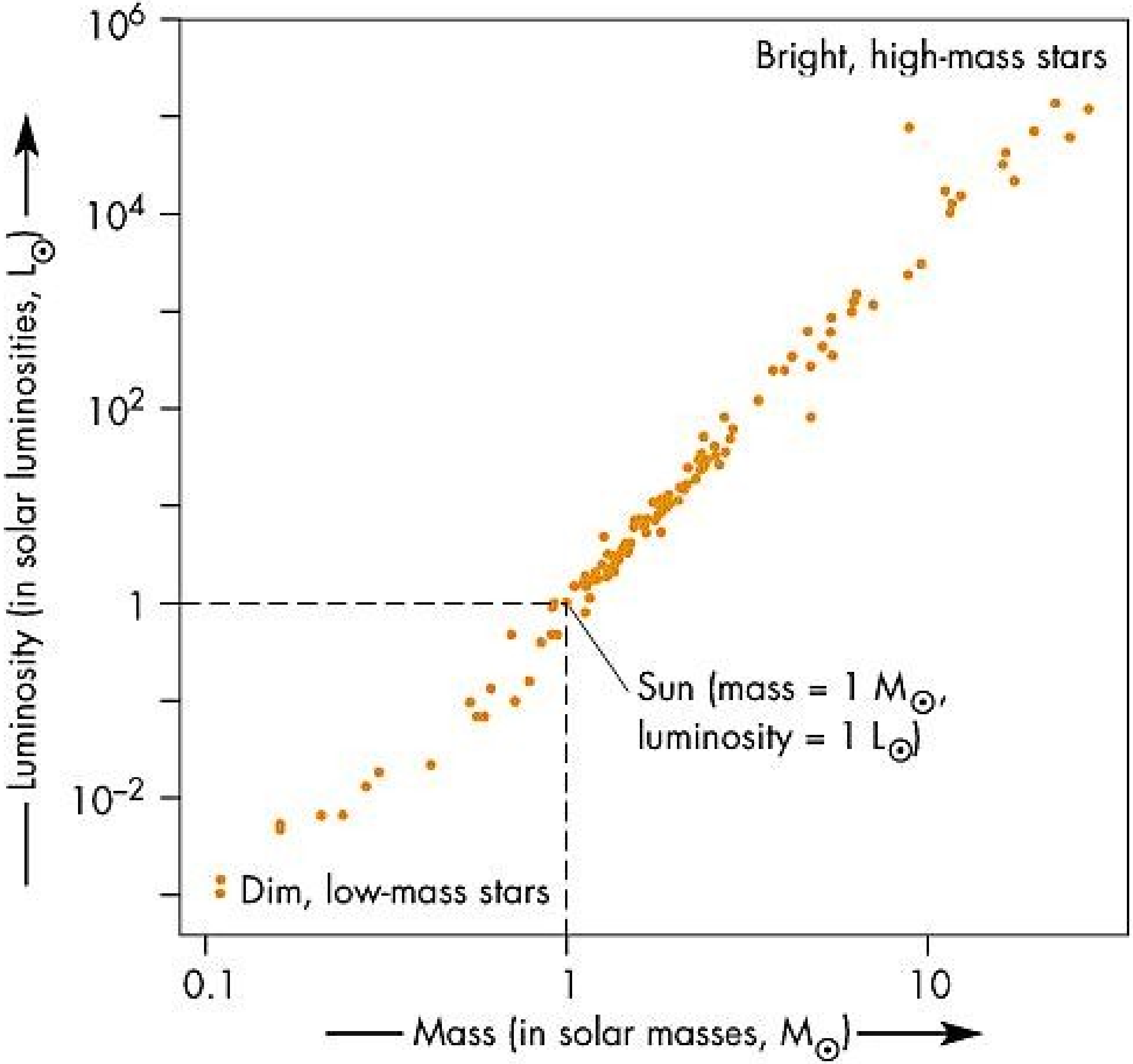
Use fact that a 1 solar mass star lives about 10 Gyr = 10 billion years = 10^{10} years on the main sequence.

$$\frac{\text{Lifetime}_B}{\text{Lifetime}_A} = \frac{\text{Mass}_B}{\text{Mass}_A}\left(\frac{\text{Luminosity}_B}{\text{Luminosity}_A}\right)^{-1}$$

Star A = Sun, Star B = star of interest

$\text{Mass}_B/\text{Mass}_A = 5$

Mass-Luminosity relation on the main sequence



$L_B/L_A = 500$

$$\frac{\text{Lifetime}_B}{\text{Lifetime}_A} = \frac{\text{Mass}_B}{\text{Mass}_A}\left(\frac{\text{Luminosity}_B}{\text{Luminosity}_A}\right)^{-1}$$

$$\frac{\text{Lifetime}_B}{\text{Lifetime}_A} = \frac{5}{1}\left(\frac{500}{1}\right)^{-1} = \frac{1}{100}$$

$$\text{Lifetime}_B = \frac{\text{Lifetime}_A}{100} = \frac{10^{10}\,\text{years}}{100} = 10^{8}\,\text{years}$$

The most massive star on the main sequence in a star cluster has a mass of 5 solar masses. Approximately how old is the cluster?

A) 1 Myr
B) 10 Myr
C) 100 Myr
D) 1 Gyr

$$\frac{\text{Flux}_B}{\text{Flux}_A} = \frac{\text{Luminosity}_B}{\text{Luminosity}_A}\left(\frac{\text{Distance}_B}{\text{Distance}_A}\right)^{-2}$$

$$\frac{\text{Luminosity}_B}{\text{Luminosity}_A} = \left(\frac{\text{Radius}_B}{\text{Radius}_A}\right)^{2}\left(\frac{\text{Temperature}_B}{\text{Temperature}_A}\right)^{4}$$

$$\frac{\text{Lifetime}_B}{\text{Lifetime}_A} = \frac{\text{Mass}_B}{\text{Mass}_A}\left(\frac{\text{Luminosity}_B}{\text{Luminosity}_A}\right)^{-1}$$