Astro C10, Quiz 2
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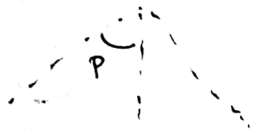
Favourite ~~book~~ veggie: carrot

Show all work; I can only give partial credit if you write *something* down. Possibly useful information & equations are on the back side. You are all fantastic – good luck, and may the odds be ever in your favour!

1. **Life, the Universe, and Everything**
Star Ben is a main sequence star that you observe for 6 months between December and July.

(a) Much to your unsurprise[1], Star Ben appears to be in a different location on the sky in July than in December. The location on the sky has shifted by 0.5". How far away is Star Ben?



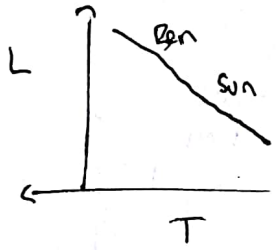
$2p = 0.5 \rightarrow p = 0.25$

$p = \frac{1}{d} \rightarrow d = \frac{1}{p} = \frac{1}{0.25} =$ 4 pc

(b) You take a spectrum of Star Ben and determine Ben to be of spectral type O. What can you say about Star Ben's mass, radius, and temperature compared to that of the Sun? Just give qualitative answers.

$M_B > M_\odot$
$R_B > R_\odot$
$T_B > T_\odot$

(c) Draw an **HR/luminosity-temperature diagram**. Label your axes. Draw the **main sequence** on it. **Label** where Star Ben and the Sun would lie on your diagram.



(d) $H\alpha$ is the name of the $E_2 \rightarrow E_3$ transition in Hydrogen. It occurs at in intrinsic $\lambda = 656.28$ nm. In Star Ben, you see this line vary over time, with a period of 2 months, between 656.27 and 656.29 nm. Briefly give a possible explanation for this.

Doppler Wobble due to orbiting planet
or ☆ is in binary w/ another ☆
} these are physically the same effect both are causing Ben to "orbit" = move!

(e) Upon looking more closely, you find that Star Ben is actually in a binary system! You determine Ben's mass to be 20 $M_\odot$. Your friend Sarafina proposes that the companion star is a white dwarf. **Is this explanation likely?** Why or why not?

[1] I hope...

Not possible. $t_{MS} \propto M^{-3}$
W.D originates from ☆ of $M < 8 M_\odot$, Ben is $20 M_\odot$
If Ben is still on MS, then ~~the companion must be~~ any companion that would form a WD should also be

(Remember: ☆s in binary have the same age!)

(f) Now assume the companion is a 2 $M_\odot$ main-sequence star. How much fainter is it than the Star Ben?

$$\left(\frac{L_B}{L_C}\right) = \left(\frac{M_B}{M_C}\right)^4 = \left(\frac{20}{2}\right)^4 = 10^4$$

(g) How much closer would you have to place this companion to us (relative to Star Ben), to perceive it and Ben with the same brightness on Earth?

$$1 = \frac{b_B}{b_C} = \frac{L_B/4\pi d_B^2}{L_C/4\pi d_C^2} = \frac{L_B}{L_C}\left(\frac{d_C}{d_B}\right)^2$$

(Both we want same apparent brightness)

$$1 = \underbrace{10^4}_{\text{from (f)}} \times \left(\frac{d_C}{d_B}\right)^2 \rightarrow \frac{d_C}{d_B} = 10^{-2}$$

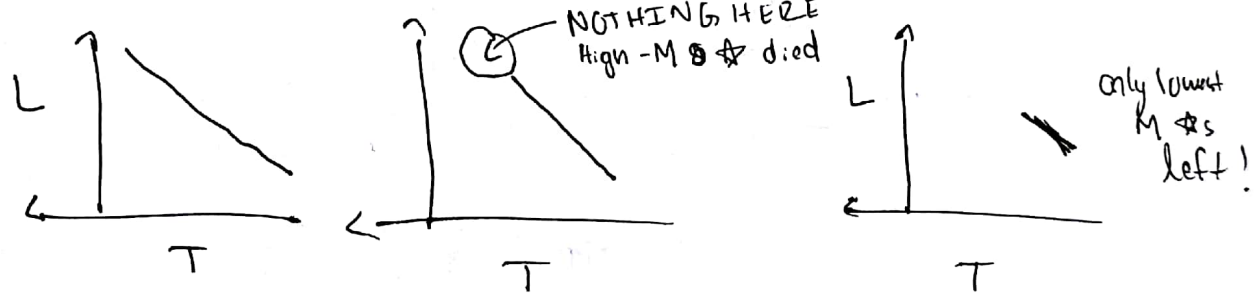
(h) Assuming no binary mass transfer, what will the **fate of each star be** in 5 billion years? At that time, for each star, who **will be winning**: gravity, pressure, or neither (tie)? **Explain.**

Ben: BH, gravity wins (NS with "tie" also okay)

$t_{MS} \propto M^{-3}$ → Companion: W.D., tie (e^- degen = gravity)

→ 2 $M_\odot$ ☆ has M.S life of ~1 billion yrs

(i) Finally, suppose Ben and its companion live in a newly-born star cluster. **Draw** the HR diagram for the cluster now, in 10 million years, and in 1 billion years. **Label** where the Sun lies on the diagram. You can draw three separate plots or one plot, just clearly label everything!



A smattering of stuff you may or may not need:

Information about the Sun:

$\lambda_{peak,\odot} \approx 500$nm

The Sun is a G-type star with a main sequence lifetime of 10 billion years.

Equations:

$\lambda_{max} T = .002898$ meter-Kelvin

$b = \frac{L}{4\pi d^2}$

$p = 1/d$ (units: arcseconds, parsecs)

$L_{star} = 4\pi R^2 \sigma T^4$

$L \propto M^4$

$t_{MS} \propto \frac{1}{M^3}$

Only Boring Astronomers Find Gratitude Knowing Mnemonics