

UC Berkeley
Astronomy Department
Astro C10 – QUIZ #1

UGSI: Eli Gendreau-Distler

Name: _____

Discussion Section: _____

Student ID Number: _____

This quiz contains 3 questions and will be graded out of 50 points. The questions include material from the first three homeworks of the course, with an emphasis on content we have discussed in section. I suggest that you start by looking over all the questions to see which questions you feel most comfortable answering first, then circling back to the challenging questions at the end. **To receive full credit, you must show your work, include units, and circle your final answers.** Good luck!

Distribution of Points

Question	Points	Score
1	18	
2	18	
3	14	
Total:	50	

Useful Constants and Equations

Constants

The Speed of Light = c

$$h \approx 6 \times 10^{-34} \text{ J s}$$

Wavelength = λ

$$1\text{m} = 10^9 \text{ nm} = 10^{-3} \text{ km}$$

Frequency = f

$$\sigma \approx 6 \times 10^{-8} \text{ watt/m}^2\text{K}^4$$

Energy = E

$$c = 3 \times 10^8 \text{ m/s} = 3 \times 10^5 \text{ km/s}$$

Temperature = T

Luminosity = L

Equations

$$[\text{Wavelength vs Frequency}] \quad c = \lambda f$$

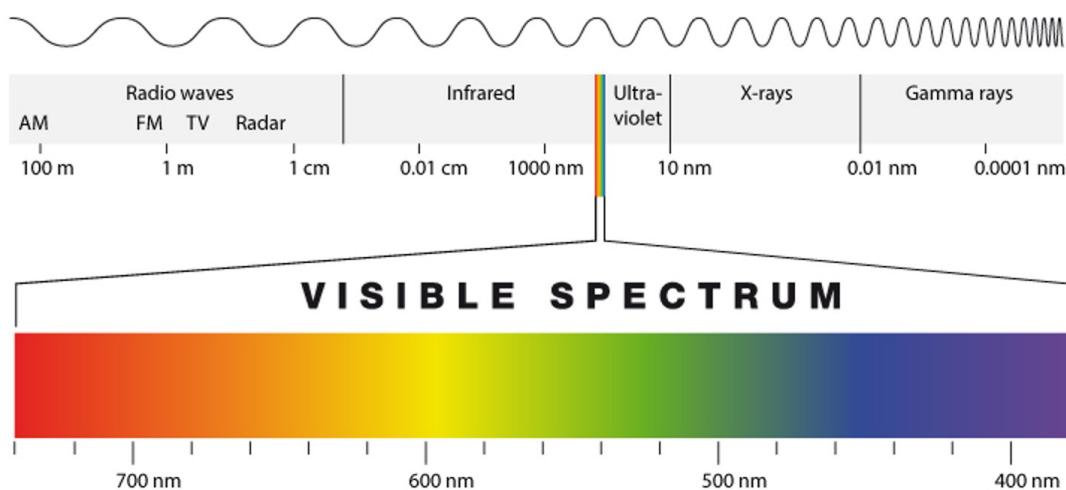
$$[\text{Energy vs Frequency}] \quad E = hf = \frac{hc}{\lambda}$$

$$[\text{Color vs Temperature}] \quad \lambda_{peak} \cdot T \approx 3.0 \times 10^6 \text{ nm K}$$

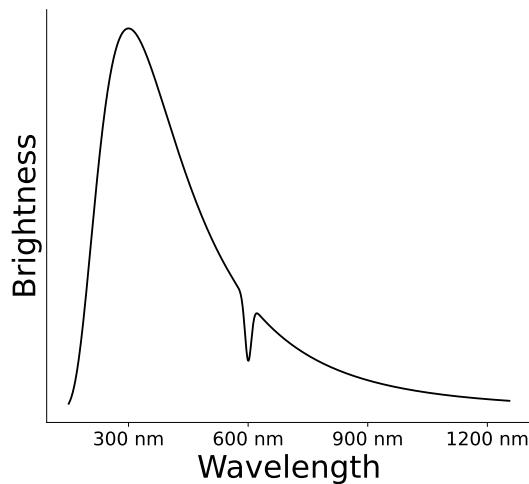
$$[\text{Luminosity vs Temperature}] \quad L = A\sigma T^4$$

$$[\text{Doppler Shift}] \quad \frac{v}{c} = \frac{\Delta\lambda}{\lambda_0} = \frac{\lambda - \lambda_0}{\lambda_0}$$

Electromagnetic Spectrum



1. The plot below shows the spectrum of Star Athena, which you may assume is a blackbody.



(a) (5 points) What is the temperature of Star Athena in units of Kelvin (K)? Assume the star is not moving relative to you.

(b) (5 points) The absorption line in the spectrum above results from electrons jumping between energy levels E_1 and E_2 of the imaginary element Stellarium in Athena's atmosphere. What is the energy difference $E_2 - E_1$ between the first two energy levels for this element?

You may leave your answer in terms of constants such as h and c , but make sure the units cancel properly such that if you were to evaluate the numerical answer you would obtain a result in units of Joules (J). For reference, $1 \text{ J} = 1 \text{ kg} \frac{\text{m}^2}{\text{s}^2}$

- (c) (3 points) Does the absorption line occur because of electrons jumping from E_1 to E_2 , or because of electrons jumping from E_2 to E_1 ? Explain.
- (d) (5 points) How can this kind of spectrum be used to measure velocities? Be sure to include a specific equation, indicate which quantity you are trying to solve for, and explain qualitatively what values you would plug in for the remaining quantities.

2. Consider two stars, Star Apollo and Star Hera, which can be approximated as blackbodies. The temperature of Star Apollo is twice the temperature of Star Hera. For parts (a) and (b) of this question, you may assume the stars are not moving.

(a) (6 points) Suppose Star Hera's spectrum peaks at a wavelength of 1000 nm. At what wavelength does Star Apollo's spectrum peak?

(b) (2 points) Is the peak wavelength of Star Apollo's spectrum within the visible part of the electromagnetic spectrum? If you did not solve part (a), you may use 600 nm as the peak wavelength of Star Apollo's spectrum.

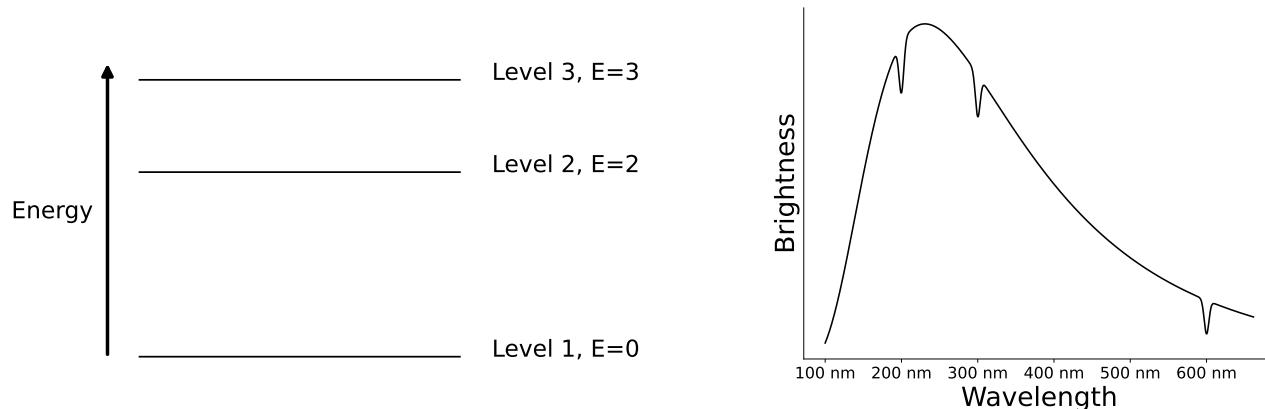
(c) (5 points) Suppose the peak wavelength of Star Hera's spectrum is observed at 1200 nm. How fast is Star Hera moving in terms of the speed of light?

Express your answer as a fraction such as “velocity = $(\frac{a}{b}) c$,” where c is the speed of light.

(d) (2 points) Is Star Hera moving toward or away from us? Explain.

(e) (3 points) How fast is Star Hera moving in kilometers per second (km/s)? If you did not solve part (c), you may use $v = \frac{1}{4}c$.

3. The imaginary element Celestium has three energy levels, as shown in the diagram on the left (with energies listed in arbitrary units). The absorption spectrum on the right is produced when a blackbody shines through a cloud of Celestium gas.



- (a) (7 points) Label which absorption line corresponds to which electronic transition and justify your labeling. It is sufficient to write $E_x \rightarrow E_y$ next to each absorption line (where x and y are the initial and final energy levels, respectively) and show your reasoning.
- (b) (7 points) Suppose a photon with frequency f was emitted from an electron in Celestium jumping from E_3 to E_2 . Could a photon of frequency $2f$ be absorbed? Explain how.