ASTRONOMY 12

Problem Set 2 – due Thursday, Feb. 4, 2016

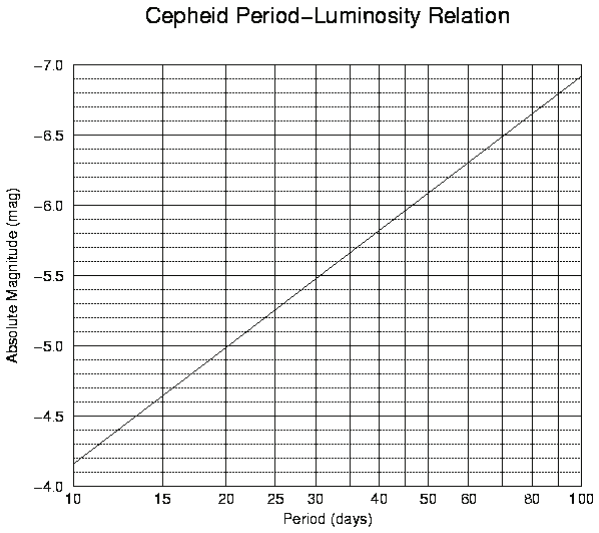
Longer problems

1) Supernovae are very bright, but do you think that they pose a biological hazard? Consider a typical (Type II) supernova with $L_{\rm peak} = 10^9$ solar luminosities. (This kind comes from the death of a massive star and is more common than the brighter Type Ia supernovae discussed so far in class). At what distance, in parsecs, would that supernova have a brightness equal to that of the sun? At what distance would it be 10 times fainter than the sun? Compare that to the distance to the nearest star, Alpha Centauri. (nb. 1 AU = 1/206265 pc). This is a question about fluxes.

2) A nearby star has a parallax angle of 20 milli-arcseconds, i.e., p = 0.02". If that star has an apparent magnitude of m = 6.0, what is its absolute magnitude? Is it more or less luminous than the sun? (Ignore bolometric corrections.)

3) a) Given below is the approximate period-luminosity relation for *Type I* Cepheid Variables. If a Type I Cepheid variable star is observed (in another galaxy) with a period of 30 days and if that Cepheid has an apparent magnitude m = 20.0, what is the distance to that Galaxy in parsecs?

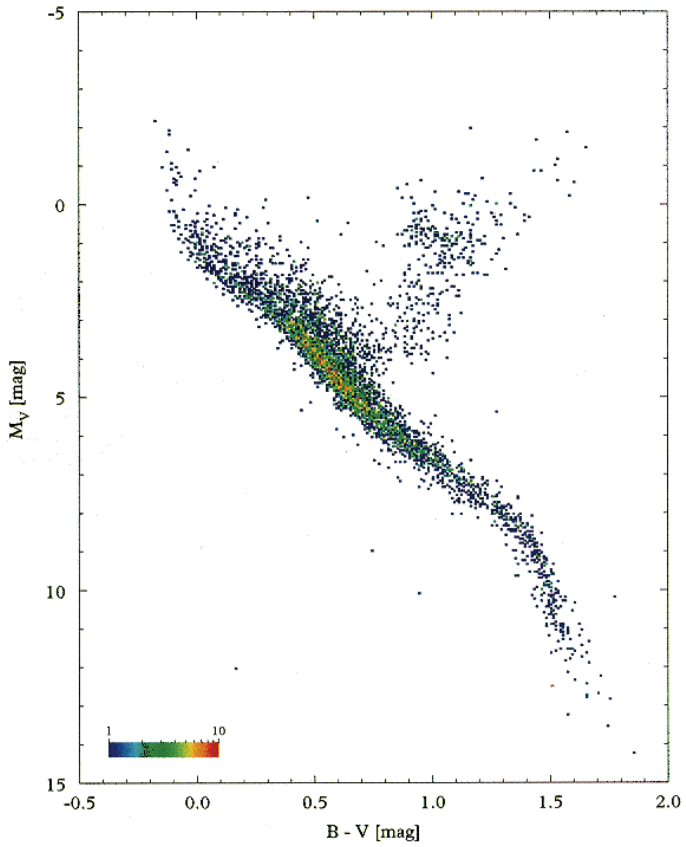
b) Suppose another Cepheid also with m = 20.0 had that same period, but was actually *Type II* and thus had an *absolute* magnitude 1.5 magnitudes larger (i.e., 1.5 added to its magnitude making it a larger number and therefore fainter) than plotted here, [or alternatively the diagram had been miscalibrated by 1.5 magnitudes due to the neglect of dust and reddening], what would be the revised distance? By what factor does your answer in b) differ from that in a)?



4) Given below is a HR-diagram prepared from data taken by the Hipparcos satellite using 4477 stars whose parallax distance is accurately determined. Consider a *main sequence* star with color index B-V = 0.65. What would be its absolute magnitude (as accurately as you can read the graph)? If another main sequence star much farther away had the same color index (i.e., B - V = 0.65) and was observed to have an apparent magnitude of 15.0, what would be the distance to that star in parsecs?

b) The (B-V) for the star Wolf-28 is 0.55 and its absolute visual magnitude is 14.19. Look where this point would be on the graph. What is special about this star compared to all the others? For example, how would its radius and temperature compare to the sun (qualitatively, no calculation necessary).

c) Betelgeuse, obviously one of the brighter stars in the sky has (B-V) = 1.85 and absolute visual magnitude -5.9, just off scale here. Again, how would its radius and temperature compare with that of the sun - qualitatively, not a number?



5) The average temperature of the earth worldwide, night plus day, is 288 degrees K (15 degrees C). Assume that the earth radiates like a perfect blackbody and ignore the Earth's atmosphere. a) At what wavelength would most of the energy come out? Is this wavelength in the optical, radio, uv, microwave band or what? b) The radius of the earth is 6.38 x 10^8 cm (6380 km). What is the luminosity of the earth in erg s^{-1}?

How does that luminosity compare to the heat flux diffusing out from the interior of the hot core of the earth, 4.5 $\times 10^{20}$ erg s^{-1}?

6) a) Star A and Star B both have the same luminosity. If Star A has a higher surface temperature than Star B, how do the radii of both stars compare to each other? No numbers are needed, but justify your answer using a relation/equation from class.

b) The star Rigel has a luminosity approximately equal to $10^5 L_\odot$, and its radius is about $75 R_\odot$. How does its effective surface temperature compare with that of the Sun? Use ratios to solve this problem, and give your answer relative to the sun's surface temperature $T_\odot = 5800$ K.

c) Would Rigel appear redder or bluer than the Sun? Explain your answer.

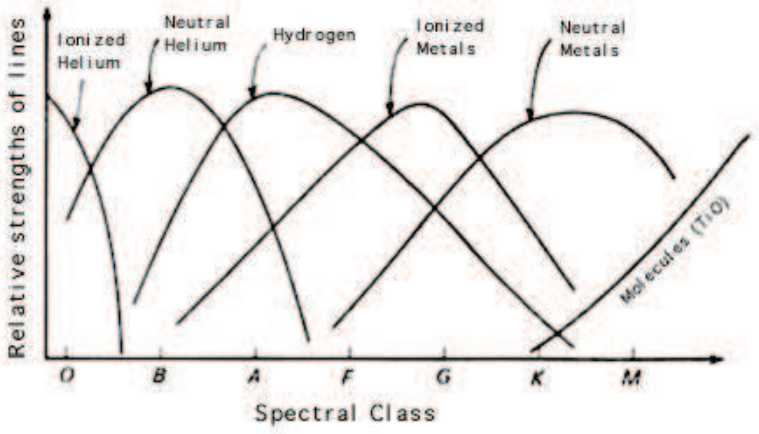
7) The absorption lines seen in spectra of stars provide information about their surface temperatures and luminosities. The graph below shows the relative strengths of absorption lines due to different atoms and molecules as a function of spectral type.

a) The spectrum of Star 1 has strong absorption lines due to ionized helium. Star 2's spectrum shows strong lines of neutral helium. Which star is hotter?

b) In which star would you expect to see strong absorption lines due to molecules like titanium oxide (TiO): Star 3 (surface temperature of 1,000 K), or Star 4 (surface temperature of 5,000 K)?

c) Why would one NOT see strong lines due to ionized helium or molecules in an F star? In other words, why is the surface temperature of an F star not ideal for the presence of ionized helium or molecules?

d) Using the tables in the lecture notes, give the *approximate* luminosities of Stars 1, 2, 3, and 4 from above in solar luminosities ($L_\odot$). Assume the stars are all on the main sequence.



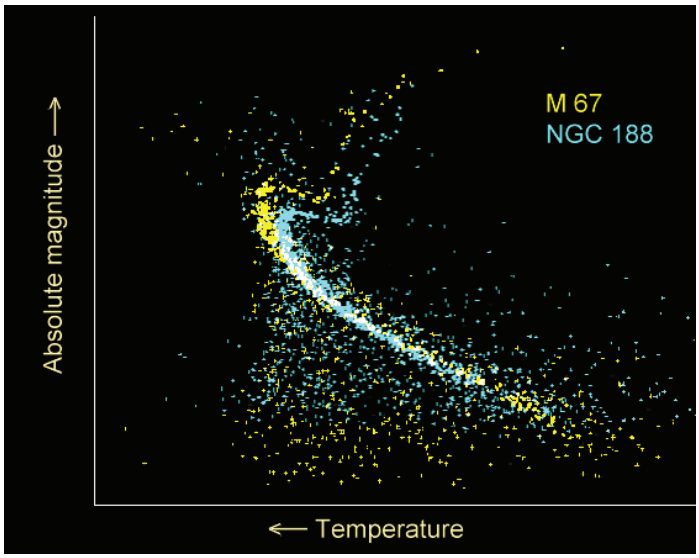
Shorter problems

1) A new planet is discovered orbiting a nearby star, not the sun. The star is a little less massive than the sun and therefore has a lower luminosity, in this case half that of the sun. Assuming circular orbits and that the earth is 1 AU from the sun, how many AU would the newly discovered planet need to be from its parent star to receive the same *flux* as the earth receives from the sun? Other factors, notably rotation and the greenhouse effect can change your answer, but this would be roughly the "habitable zone" for that star. Does your answer depend on the size (i.e., radius) of the planet?

2) Using the descriptors upper and lower and left and right, where in the Hertzsprung Russell diagram are stars with the following characteristics located? a) cool, luminous, b) cool, faint, c) hot, luminous, and d) hot, faint. To which category do red giants belong? White dwarfs?

3) The star Betelgeuse has a surface temperature of about 3000 K. The star Rigel has a surface temperature of about 12000 K. How much longer or shorter is the peak wavelength of emission from Rigel compared to Betelgeuse? Which star looks redder?

4) The Hertzsprung Russell diagrams for two clusters are plotted on the same scale below. Which contains the most massive main sequence stars? Which is the older cluster? Explain briefly.



5) Spectroscopic analysis of a star shows it to be a main sequence star of spectral class F5. From the tables in the notes, what is the absolute visual magnitude of the star and its bolometric correction. What would be its apparent visual magnitude at 10 pc?

6) How many electrons have been stripped (removed) from the neutral atom in order

to make the following ions? a) H I, b) He I, c) H II, d) He II, e) C IV ?

7) A star moving *towards* you at 150 km s^{-1} has a spectrum containing the Balmer series of hydrogen. The Balmer-alpha (H_α) line in the laboratory from hydrogen at rest is found at a wavelength of 6562.8 Angstroms. At what wavelength would that line appear in the star's spectrum as observed from the earth (because of the Doppler shift)?

8) Which transition in the neutral hydrogen atom gives rise to the photon with the longer wavelength (redder light) Balmer alpha or Balmer beta? Explain briefly.