Problem set #2

Problem 1 *Flux from the sun in a clever way*

As experiments show, on Oct. 1 the sun subtends an angular diameter of 32 arcmin.

(a) Calculate the solid angle $\Omega_\odot$ subtended by the sun, in steradians.

(b) Show that the flux (in $\mathrm{W\,m^{-2}\,s^{-1}}$ or its cgs equivalent) of solar radiation on earth is $F = I(T_\odot) \cdot \Omega_\odot$ with $T_\odot = 5777$ K, and calculate this value numerically. Note that to calculate the flux from a blackbody of known temperature (or other source of known specific intensity), *you do not need to know the distance or luminosity, but only the temperature and angle subtended! Both of these are direct observables, unlike distance and luminosity ...*

(c) Show that the answer to the previous part is the same as you would get by the more obvious but unnecessarily complicated method $F = L_\odot/(4\pi a^2)$, with $a = 1$ AU and $L_\odot = 4\pi R_\odot^2 \sigma T_\odot^4$.

Problem 2 *Alpha Centauri*

The star Proxima Centauri, probably bound gravitationally to α Centauri (α Cen), is a small main-sequence star of mass 0.123 solar. Using the empirical scaling between the mass and luminosity from the textbook, and between mass and radius (you can assume it's linear, $R \sim M$), compute Proxima's effective temperature T_{eff}. Comparing with sun's temperature, prove that the star appears much redder than the sun.

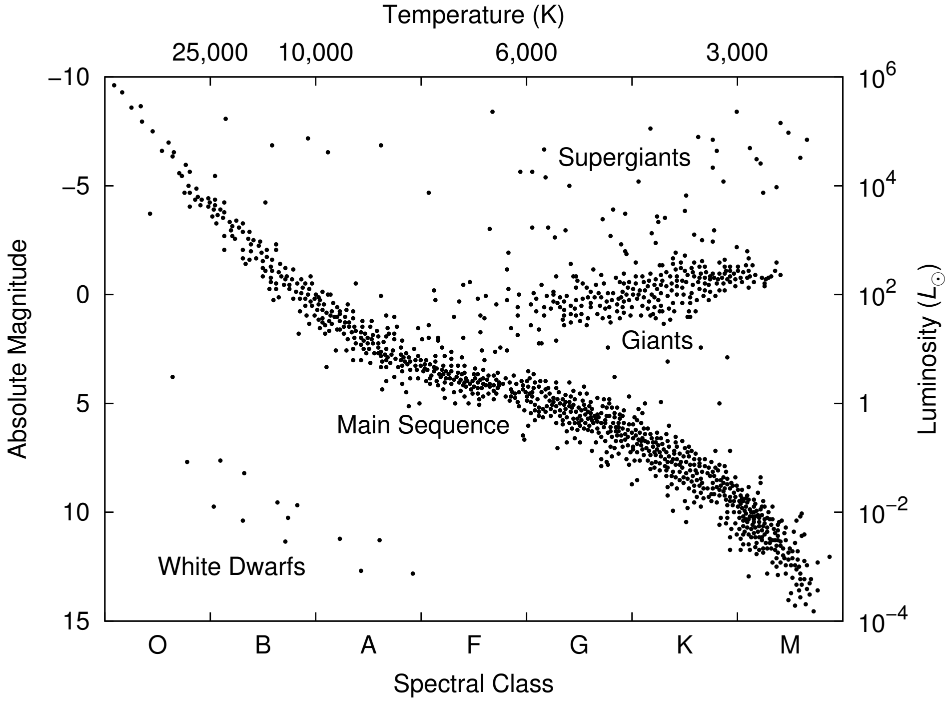
Compute the effective temperatures of the other two stars (1.1 and 0.91 solar masses) in the α Cen system and draw conclusions about their color. Predict the wavelength at which maximum flux of radiation is emitted for all the stars including the sun, given by Wien's law.

Compare the results you obtained from the scaling law with the more exact data on the wiki page. Comment on the source of differences, if any.

See: http://en.wikipedia.org/wiki/Proxima_Centauri
http://en.wikipedia.org/wiki/Alpha_Centauri

Problem 3 *HRD exploration*

Consider the following Hertzsprung-Russell diagram:



(a) You observe a star (Star A) that is bluish in color. You measure its spectrum, and find that the spectrum F_λ reaches a peak at an ultraviolet wavelength of 1500 Å. What is the temperature and spectral type of this star?

(b) You observe a star (Star B) that is reddish in color. You measure its spectrum, and find that the spectrum F_λ reaches a peak at a red/infrared wavelength of 7800 Å. What is the temperature and spectral type of this star?

(c) Star A and Star B have the same observed brightness. You measure the parallax of Star A to be $0.0080''$, and the parallax of Star B to be $0.080''$. What is the ratio of luminosities of the two stars?

(d) If you determine that Star A is a main sequence star, what kind of star (white dwarf, main sequence, giant, or supergiant) is Star B? Explain.

Problem 4 *Key questions*

Answer the following questions summarising the basic properties of stars and stellar spectra:

- What is the Harvard classification of stars? Which stellar property is the dominant varying parameter along the Harvard sequence?
- What is the definition of effective temperature T_{eff} and what range of effective temperatures is observed in stars?
- What is a stellar spectrum? What are the important absorption features in the optical region of stellar spectra? What are the main differences between spectra of different stellar types?
- What is the Hertzsprung-Russel diagram?
- What are the main differences between colour-magnitude diagrams of open clusters and globular clusters?
- How can you determine radii and masses of stars? What range of radii and masses do stars show?
- For stars on the main sequence, how are luminosities, effective temperatures, radii and masses related? And for a white dwarf?