ASTR 545
SPRING 2010
Homework 3
DUE: September 17, 2010

1. Using the table from Aspulund, Grevess, & Savaal (2004, astro-ph/0410214) given in the class notes...

   (a) Compute the photospheric abundance fractions, α_k, for the first 30 elements (up to zinc). Be sure to present the equations you use. You can ignore all elements heavier than zinc in your calculation. Present your results on a histogram plot of $\log \alpha_k$ versus atomic number, emulating the plot in the class notes of $\log n_k/n_{\rm H}$ versus atomic number. If you write a code or use a spread sheet, present your code/sheet; otherwise show your calculations.

   (b) Compute the mass fractions for hydrogen (X), helium (Y), and metals (Z) for the sun for all elements up to and including zinc. Compare them to the solar values given in the notes. Is there a reason that your computed values might differ from the accepted solar values?

   (c) Given that $\rho = \sum n_k A_k m_{\rm amu}$, compute the mass fraction, x_k, of the most abundant metal species (heavier than helium) for the photospheric abundance fractions you computed in part (a). Which element is this? Beginning with the definition of the mass fraction, begin by deriving the equation you will use in terms of the abundance fractions. Report both your value of $\rho/n_{\rm H}$ and your value of x_k.

   (d) If a given star has [Fe/H] $= -0.63$, what is the value of $n_{\rm Fe}/n_{\rm H}$ in this star. Show your work.

   (e) If this same star has [Mg/H] $= +0.26$, then what is [Mg/Fe] for this star? Show all steps of your work.

2. Consider the equivalent width of an Hα absorption line in a stellar spectrum for which the star exhibits a surface temperature of $T = 5000$ K and microturbulent velocity of $v_{\mu t} = 10$ km/s.

   (a) If the atmosphere has a constant density of $n_{\rm HI} = 10^7$ cm^{-3} and a thickness of 600 km and you assume the line resides on the linear part of the curve of growth, what is the equivalent width in angströms? Show your work.

   (b) What is the value of thermal Doppler b parameter, b_{th}(H), in km/s? Accounting for the microturbulence, what is the value of the total Dopper b parameter, b_{tot}(H), in km/s?

   (c) If the line is on the flat part of the curve of growth, compute the ratio $W_{+\mu t}/W_{-\mu t}$, where $W_{+\mu t}$ is the equivalent width including the effects of mictroturbulence and $W_{-\mu t}$ is the equivalent width neglecting microturbulence. Show the equation(s) you use and your work.

3. A star on the HR diagram has $T = 3000$ K, $L/L_\odot = 10^4$, and $M/M_\odot = 3$.

   (a) Compute $\log(g/g_\odot)$ for this star.

   (b) If the mass of this star were increased to $M/M_\odot = 30$, but the surface gravity was the same as in part (a), compute what the luminosity ($L/L_\odot$) would be?

4. Consider Figure 13.7 of Gray.

   (a) Explain physically why the curves behave they way they do as a function of temperature. What are the governing physical processes and what equations are invoked to compute the curves?

   (b) Explain physically why there are different curves for different $\log g$ and why they behave relative to one another as they do for changing $\log g$. In your answer, incorporate the behavior of the lines as illustrated in Figure 13.10 form Gray.

   (c) Physically, what causes pressure broadening? Briefly, what are the four types of pressure broadening that we considered in lecture? Provide a very brief synopsis of each (i.e., for each which particles are affected, which particles are the perturbers, and which lines are predominantly affected.