# Assignment 3 — due Friday October 16th [*Revision* : 1.2]

This assignment comprises questions **8.5**, **8.8**, **8.10**, **8.14**, and **8.16** from Chapter 8 of Ostlie & Carroll, plus the following *EZ-Web* calculation task:

1. Use a web browser to visit the *EZ-Web* site (`http://www.astro.wisc.edu/~townsend/static.php?ref=ez-web`).
2. Read through the documentation on the site.
3. Construct an evolutionary sequence of stellar models leading up to the present-day Sun, by submitting a calculation with the following parameters:

   **Initial mass:** 1.0

   **Metallicity:** 0.02

   **Maximum Age:** 4.5e9

   **Maximum Number of Steps:** 0

   **Create Detailed Structure Files:** yes (checked)

   **Email Address:** Your email address
4. You will receive an email telling you how to download a zip file containing the calculation results. Unpack this file.
5. Within the zip file, the text file `structure_00065.txt` contains the detailed structure for the present-day Sun. The format of this file is described on the *EZ-Web* site.
6. Use the data in the detailed structure file to plot the ionization fraction of hydrogen $x$ as a function of $\log_{10} T$. The ionization fraction is given by

   $$x = \frac{X^+}{X}.$$

   Here, $X$ is the so-called 'mass fraction'[1] of hydrogen (H I *and* H II), and $X^+$ is the mass fraction of ionized hydrogen (just H II). Both $X$ and $X^+$ are tabulated in the detailed structure file. Make sure your graph has appropriate scales, labels and units on the axes.
7. On the same graph, plot the ionization fraction that is predicted by Saha's equation. Why do the two curves diverge toward the center of the Sun?

Bonus points can be obtained by answering the following question:

Use *EZ-Web* to calculate a stellar model with the same initial mass and age as the present-day Sun, but with a metallicity of $Z = 0.0001$. Determine the effective temperature of this metal-poor Sun, and calculate the wavelength $\lambda_{\rm max}$ of its Wien peak. Use your result to explain why the early universe was rich in UV radiation.

[1] The mass fraction of an element or ion is the fractional composition by mass of that element or ion. For instance, with a hydrogen mass fraction of $X$, one gram of stellar material contains $X$ grams of hydrogen. Mass fractions are dimensionless, and always less than or equal one.