Assignment 6 — due December 12th [Revision : 1.2]

1. Use EZ Web to calculate solar-metalicity models with \( \log M/M_{\odot} = -0.4, -0.2, 0.0, \ldots, 1.2, 1.4 \). Set the maximum model number to 100,000, and the maximum model age to \( 10^{20} \); this will ensure that EZ Web follows as much of the evolution as possible. You only need to generate summary files; model files are not required. With the data from these calculations, plot the evolutionary tracks of the models in a Hertzsprung-Russell diagram. Your diagram should cover the ranges \( \log T_{\text{eff}} = [4.6, 3.4] \) and \( \log L/L_{\odot} = [-2, 6] \).

On your HRD, mark (by hand or using the computer) the following features:

- The zero-age main sequence (for all tracks)
- The episode of overall Kelvin-Helmholtz contraction during hydrogen burning (for \( \log M/M_{\odot} \geq 0.2 \))
- The point where hydrogen shell burning begins (for all tracks)
- The point of helium core ignition (for \( \log M/M_{\odot} \geq 1.4 \))
- The general location of the Hayashi line
- The red-giant branch (for \( -0.2 \leq \log M/M_{\odot} \leq 1.2 \))
- The asymptotic giant branch (for \( 1.4 \leq \log M/M_{\odot} \leq 1.8 \))
- The degenerate cooling curve for \( \log M/M_{\odot} = -0.4 \)

2. For the models calculated in the previous question, plot the trajectories followed by each model in the \( \log \rho_c - \log T_c \) plane (where \( \rho_c \) is the central density, and \( T_c \) is the central temperature). On your plot, also show (as a dashed line) the boundary defined by

\[
\frac{T_c}{\rho_c^{2/3}} = 1261 \text{ K m}^2 \text{ kg}^{-2/3},
\]

which divides the plane into regions where electron degeneracy is important (low-\( T_c \), high-\( \rho_c \)) or unimportant (high-\( T_c \), low-\( \rho_c \)). Moreover, show (as a dotted line) the threshold \( T_c \approx 10^8 \text{ K} \) for helium ignition.

From your diagram, determine which models will undergo a helium flash, and which will never ignite helium. Justify your answers.

3. Fig. 1 shows spectra for four types of supernova: Ia, Ib, Ic and II. Identify which is which, and justify your answers.
Figure 1: Supernovae spectra for Q3.