In this project, you will obtain a copy of some FORTRAN code that constructs ZAMS models for a given mass and chemical composition. The code is available from the course web page and needs to be compiled and linked before it can be executed. If you are unfamiliar with how this is done, ask one of your classmates or come see me. In each part of this exercise, please explain your answers thoroughly.

Part 1 – The Location of the ZAMS and Sensitivity to Abundance

Use the ZAMS.F program to construct zero-age main sequence models. Each time the program is run, it needs to know the mass of the star in solar masses, the Hydrogen and Helium mass fractions, guesses for the central pressure, central temperature, total radius, and total luminosity. Read Appendix C in H&K and use the values in Table C.1 as a guide for these quantities. Keep track of the program’s output each time you run it in a logical and organized manner.

1.1 Use the program to produce a ZAMS for the solar composition (X=0.70, Y=0.28, Z=0.02) and masses of 0.8, 0.9, 1.0, 1.5, 2.0, 2.5, 3.0, 5.0, 9.0, and 15.0M\(_\odot\). Plot these data in an HR Diagram (Log L, Log T\(_{\text{eff}}\)) in order to construct a ZAMS. Make sure to construct the axes properly and to join the points with a line.

1.2 Investigate the effects of varying the metal abundance by doing 1.1 for Z=0.01 and 0.001 keeping Y constant.

1.3 Investigate the effects of varying the helium abundance by doing 1.1 for Y=0.25 and 0.22 keeping Z constant.

Part 2 – The Relevance of the Homology Relations

Carefully read Sections 1.5 and 1.6 in HK&T. We will now compare the results of Part 1 with the predictions of the homology relations 1.67 – 1.70 on page 25 of HK&T.

2.1 Given that \( \varepsilon = \varepsilon_0 \rho T^\gamma \), \( \kappa = \kappa_0 \rho T^{-\delta} \), and \( d \ln P = \chi_0 d \ln \rho + \chi T d \ln T \), where the variables have their usual meanings, calculate \( \alpha_R \), \( \alpha_T \), and \( \alpha_L \) for the ZAMS stars above that are less massive than 1.4 M\(_\odot\).

2.2 Calculate the radii, surface temperatures, and luminosities for these stars and compare your answers with the results of the stellar models constructed in Part 1.

2.3 Calculate \( \alpha_R \), \( \alpha_T \), and \( \alpha_L \) for the ZAMS stars above that are more massive than 1.4 M\(_\odot\).

2.4 Calculate the radii, surface temperatures, and luminosities for these stars and compare your answers with the results of the stellar models constructed in Part 1.
Part 3 – Transforming to the Observational Plane

Download the GREEN.TBL color transformation and M67 fiducial sequence (M67VI.FID) from the course web page.

3.1 Take the solar abundance ZAMS computed above and convert Log L and Log T\textsubscript{eff} to \(M_v\) and \((V-I)_o\) using the color transformation table. Utilize whatever interpolation scheme you deem appropriate making sure to describe what you did in your write-up.

3.2 Adopting a reddening of \(E(V-I) = 0.055\) for the open cluster M67, use the fiducial sequence to determine the distance modulus to M67 via the technique of main sequence fitting to the unevolved main sequence (i.e. \(V > 16\)).

3.3 How well does your value of \((m-M)_o\) for M67 agree with others in the literature?