Final Project: Due Friday, December 16 AST 8030, Fall 2016

Part 1

Create a computer model that solves the structure of a star assuming a set of central boundary conditions. Specifically, solve a star of mass $M = 7.08 M_{sun}$, with solar composition: $X = 0.7, Y = 0.28$. Use the following central boundary conditions (*cgs units*):

$\log P_c = 16.655$

$\log T_c = 7.45$

Integrate the equations of stellar structure outwards from $m = 0$ to the surface (or to where the density, temperature or pressure become negative if that happens before you reach the surface) using the appropriate microphysics. Specifically, assume that:

- *Equation of state* is given by the sum of radiation + ideal gas and fully ionized gas.
- *Energy generation* is a combination of the pp chain, CNO cycle, and triple-alpha process.
- *Opacity* is given by
  Undergrads: a combination of electron scattering, free-free, bound-free, and H- and use the analytic approximations for these.
  Grads: interpolating in the OPAL opacity tables and using the analytic approximations where the tables do not apply.

Hand in the following:

a. A printout of your code

b. The following 8 plots where m is in solar units:
- Pressure: $\log P$ vs. m (P in cgs units)
- Temperature: $\log T$ vs. m (T in Kelvin)
- Density: $\log \rho$ vs. m (ρ in cgs units)
- Radius: r vs. m (r in solar radii)
- Luminosity: L_m vs. m (L_m in solar luminosities)
- Opacity: κ vs. m (κ in cgs units)
- Energy generation rate: ε vs. m (ε in cgs units)
- Ratio of radiative to adiabatic gradient vs. m (this is >1 in convective regions)

c. The values for the final radius and luminosity of the star (in solar units)

d. A list of the main assumptions you made in this calculation and the main things a more accurate model would have to include.

Part 2 (for graduate students or very ambitious undergrads)

Generalize your model so that it does not need to know the exact central boundary conditions. Run the model on a star of mass $M = 2.82 M_{sun}$ with composition: $X = 0.7, Y = 0.28$. Hand in your code, produce the same plots as in part 1, and list the final values of central temperature, central pressure, total radius, and total luminosity.