Astronomy 241 Problem Set #6

Due 19 March 2024, in Box

Please submit your work in PDF form, for which the filename includes your name(s) and the number of the assignment, e.g. payne_hw1_solo.pdf or baade-zwicky_hw2_team.pdf.

If it's being submitted for a regrade, prepend Regrade_ to the file name.

All solo problems:

M. (Like C&O 10.20.) Using your program from Problem Set #5, calculate and plot the density $\rho(r)$, pressure $P(r)$, temperature $T(r)$, and the criterion for convective instability,

$$C(r) = \frac{T}{P}\frac{dP}{dT} - \frac{\gamma}{\gamma - 1} < 0 \quad \text{if unstable,}$$

for a nonrelativistic ideal-gas polytrope (n = 3/2, γ = 5/3) with $M = M_\odot$ and $R = R_\odot$. Compare these results in detail with the standard solar model in C&O chapter 11, Figures 11.4, 11.6 and 11.7. Comment on the differences. Does the polytrope have convection zones?

N. Neglect fusion power besides the p-p chain, and use the p-p energy generation rate introduced in class on 15 February 2024 to calculate and plot the luminosity gradient, dL_r/dr, and the luminosity generated within radius r, $L_r(r)$. Again compare these results in detail with the standard solar model, C&O Figure 11.5. Use this result and that of problem M to explain why we can neglect CNO and 3α fusion.

O. Continue problem N: calculate the luminosity and effective temperature of the solar-mass n = 3/2 polytrope. Express your answers in $L_\odot$ and K.