

Stars and Stellar Evolution (WS11-12)

Computer Practicum with WTTS

Exercise 8 (27/01/12)

NOTE: This exercise is a recap of the virial theorem and its importance in stellar evolution. Just to remind it to you the virial theorem states that

$$U + 2T = 0,$$

where T is the kinetic energy of the system and U is the potential energy. In a star, the kinetic energy T is related to the internal energy E_{int} through the adiabatic index γ and gravity is the source of potential energy $U = E_{\text{grav}}$, so

$$3(\gamma - 1)E_{\text{int}} + E_{\text{grav}} = 0,$$

where the adiabatic index $\gamma = 5/3$ for an ideal gas. We want to investigate stellar models to test the virial theorem and the validity of the ideal gas approximation during various stages in the life of a normal star (like our Sun) or more massive stars (e.g. the models used in the previous exercise).

15. Find your solar mass model(1M) in your **SSE_WTTS#** directory to carry out the following tasks:

1. Use the **HRD** to select an appropriate model for the **main sequence**.
2. Using the **Internals tab**, save the model as 1Msun_MS.mdl(just by right clicking on the model number you have chosen) files in your **SSE_WTTS#** directory.
3. Find the **perl script** "virial_theorem.pl" in your **SSE_WTTS#** directory. You have to edit the script to make it work with your *.mdl input files.
 - a) Using your favourite text editor, e.g. *emacs* or *gedit*, change the filename in the perlscript i.e. find the line `$input_file="*.mdl"`;
 - b) Write expressions (in Perl!) to calculate the internal and gravitational energies by using the correct expression for E_{grav} and E_{int} i.e. `$E_grav -=.....;` and `$E_int +=.....;`
4. Comment on your results obtained for $E_{\text{grav}}/E_{\text{int}}$ (from the model) with regards to validity of the ideal gas approximation.
5. How does the α factor to compare with the result you obtained in the exercise 2.3(a)? [e.g. $\alpha = 1.5$ for the main-sequence (ref. Maeder)]

16. Using the same prescription, select a **main sequence model** for a high mass star (e.g. from last class) to find value of γ and the appropriate equation of state.

17. The total energy of the star is $E_{\text{tot}} = E_{\text{int}} + E_{\text{grav}}$. Derive an expression for E_{tot} as a function of γ and either E_{int} or E_{grav} . From this, deduce what happens if the star has $\gamma < 4/3$.