Stars and Stellar Evolution (WS11-12)
Computer Practicum with WTTS

Exercise 6 (13/01/12)

<u>NOTE</u>: Check out the exciting new features added to WTTS (**/vol/software/software/astro/wtts/wtts**) over Christmas (e.g. the gnuplot options can now be changed as you like just by right clicking into the Gnuplot options!). Find out and have fun!

11. Evolve a high mass model (say $20\,\mathrm{M}_\odot$) in a separate directory (till C-burning) and answer the following:

1. Make a Kippenhahn plot with Model number on X-axis, M/Mass on Y-axis and Convection as Z-axis (might want to use Log10) and explain the convective regions you observe.
2. Change Z-axis to E_nuc (also Log10 and rescale the range appropriately) to see the different nuclear burning regions (core/shell). Comment on your findings.
3. Use the **Internals tab** to see the **onion-shell structure** of your star, by plotting the mass fractions of various elements on Y Axis (use Log10 Y and suitable range).
4. In the **HRD tab** try labelling the evolution of your star with the Central Abundance of He and identify the nuclear burning stages in order to explain the values observed along the evolutionary track.

12. Find the ZAMS folder in your **SSE_WTTS#** directory. Start WTTS from inside to load a set of zero age main sequence models (**DO NOT EVOLVE!**). Using the **Kippenhahn tab** (chose your z axis range to see the burning regions clearly, also might want to use Log10), answer the following questions :

1. Plot E_nuc on the z-axis and comment on what you observe.
2. Split E_nuc into contributions from pp and CNO burning cycles by plotting (Z-axis) the following:

   a) RPP (the pp chain burning rate),

   b) RPC (the $^{12}C(p,\gamma)^{13}N(\beta^+,\nu)^{13}C(p,\gamma)^{14}N$ burning rate),

   c) $RPNG$ (the $^{14}N(p,\gamma)^{15}O(\beta^+,\nu)^{15}N(p,\gamma)^{16}O$ rate),

   d) RPN (the $^{14}N(p,\gamma)^{15}O(\beta^+,\nu)^{15}N(p,\alpha)^{12}C$ rate) &

   e) RPO (the $^{16}O(p,\gamma)^{17}F(\beta^+,\nu)^{17}O(p,\alpha)^{14}N$ rate).

   Describe their relative contribution to the nuclear burning rate (12.1) as a function of mass.