Massive Stars: Late time evolution and wave heating

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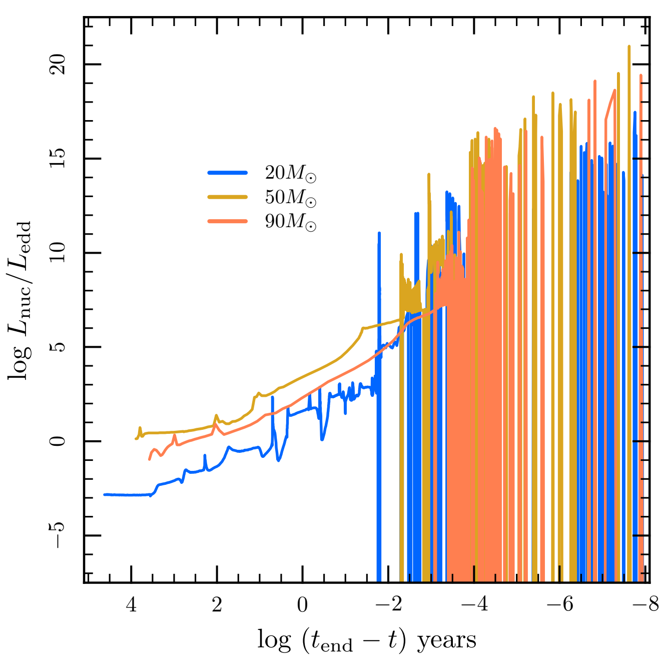
Mini-Lab Instructions

- Start a blank standard work directory
- Copy in `history_columns.list` from `mesa/star/defaults` and uncomment `log_Ledd`
- Copy in `inlist_massive_defaults` from `mesa/star/`
- Copy in `inlist_massive_pgstar` from mesastar.org and point your `inlist` to read pgstar info from this
- Change `initial_mass` value to a random number between 10 and 100
- Set `Zbase = 0.02`
- Change `Dutch_wind_eta` value to 0.3
- Add a stopping condition to stop the run when the center mass fraction for helium falls below 10^{-3} and save the model
- Load this model and run until `fe_core_infall_limit` is reached
- Note the higher luminosities (compared to $L_{\rm edd}$) and shorter evolution times for oxygen and later burning than for carbon burning.
- If you have time, you might find it more instructive to plot L fusion as a function of $\log(t_{\rm end} - t)$ to more clearly see the increase in luminosity during late stages of stellar evolution.
- That plot should look something like this:



Long Lab Instructions

- Similar to minilab, start a new work directory and copy in `inlist_massive_defaults` from `mesa/star/defaults`, and `run_star_extras.f` and `RSG_15M.mod` from the mesastar.org page for this lab
- Include the commands in `inlist_massive_defaults` to load this model
- Set `Zbase = 0.02`
- To access the routine for extra heating in the `run_star_extras.f`, you must include the command `use_other_energy = .true.`
- Then you can set `x_ctrl(1)` to control the amount of extra heating, in $L_{\rm Edd}$ units, and `x_ctrl(2)` to control the radius of energy deposition, in $R_\odot$ units
- Also set `super_eddington_wind_eta=1` to allow a mechanism for mass loss due to wave heating
- For this $15M_\odot$ model, try parameters in the range $0.1L_{\rm Edd} \leq L_{\rm wave} \leq 10L_{\rm Edd}$ and $0.1R_\odot \leq R_{\rm input} \leq 3R_\odot$.
- When your run finished, report your chosen heating rate (in $L_{\rm Edd}$ units) and radius (in $R_\odot$ units), along with your final mass and radius (again, in solar units) to the corresponding google spreadsheet for this lab
- Try running a model with super-Eddington winds off and RLO winds on instead. Set `rlo_wind_eta = 0.1` or near this value, and `rlo_wind_roche_lobe_radius` to a value between 200 and 1500 (in $R_\odot$ units) to see how this changes the late time evolution of the model
- Now download and copy in the starting model `50M_O_burn.mod` and try running it with the heating rate and deposition radius in the same range as before
- Again, report your heating rate, deposition radius, final mass, and final radius
- Note the much smaller changes for the $50M_\odot$ model because of the faster evolution times prevent the injected energy from reaching the surface before core collapse
- If you have time, you can run a high mass ($> 30M_\odot$) model from ZAMS to core collapse with various rlo wind parameters set to model the evolution of the star given that it is in a binary. See how different `rlo_wind_roche_lobe_radius` values changes the final mass at core collapse.