Assignment 2: Scaling relations

Scaling relations in astronomy can be very useful in connecting observed properties of stars to properties that cannot be easily measured. These scaling relations are typically derived using many simplifying assumptions on the physics of the star or are even entirely empirical. Their accuracy can be quantified by comparing them to a set of stellar profiles computed using a stellar evolution code, which includes more accurate treatment of microphysics, like reaction rates, equation of state, opacities, and, to some degree, convection.

The scaling relations examined in this assignment are:

- mass–radius: $R \propto M^\xi$
- mass–luminosity: $L \propto M^\eta$
- mass–central temperature: $T_\mathrm{c} \propto M^\chi$

Tasks

a) Get the template work directory from Blackboard or, if you use Git, just update via `git pull`.
b) You have to get data for a range of stellar masses. The suggested masses are $0.08 M_\odot$, $0.1 M_\odot$, $0.4 M_\odot$, $0.6 M_\odot$, $1.0 M_\odot$, $1.5 M_\odot$, $2 M_\odot$, $5 M_\odot$, $10 M_\odot$, $15 M_\odot$, $30 M_\odot$, $60 M_\odot$. Make copies of the template directory for each initial mass and adjust the inlist files accordingly. Make sure the simulation stops near zero age main sequence (ZAMS). For better performance you might want to switch off graphical output using `pgstar_flag`
c) Extract the required data for fitting the scaling laws from the last profile file in the respective directory and present them in a table.
d) Produce a log-log plot for each of the scaling laws. Can you identify distinct mass regimes with a different exponent?
e) Fit the regimes separately and determine the exponents ξ, η, χ for each. Add the fitted curves for the power laws to the respective plots for visual verification.
f) Bonus question: What is the physical reason for the different regimes in the scaling laws?

Report

Prepare a two-page (not including figures and tables) report on this assignment. The bonus question is not needed for a perfect grade but can be used to make up for a missing task on this or a future assignment.

Every group has to hand in their report at the beginning of the lab class on 30/10/2017.

Resources

- Questions regarding this assignment should be directed to `r.p.ratnasingam2@ncl.ac.uk` or `a.hindle@ncl.ac.uk`.
- The slides and the template work directory can be found on Blackboard.
- All materials are also available on https://www.mas.ncl.ac.uk/~npe27/PHY3033/
- The template work directory is also available via Git.