

Minilab 1

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In the first Minilab, we're going to consider the `astero` module's optimisation methods in isolation, without concerning ourselves with asteroseismology (yet).

1 Setting up

- Copy an `astero` work folder from `$MESA_DIR/star/astero/work` to somewhere that you'll work for all the labs. e.g. `astero_2018`. We'll keep modifying the same folder as the labs progress.
- Download the zip of materials for the labs and extract it.
- Copy the file `extras_support.f` to `$MESA_DIR/star/astero/src`.¹
- Copy the inlists (i.e. `inlist*`) from the materials to your work folder. The given `inlist_astero` mostly sticks to defaults and you won't need to modify it, and `inlist` just points to `inlist_astero`.
- We're going to fit models to a star with the following observed properties:

$$\log L/L_{\odot} = -0.08 \pm 0.05 \quad (1)$$

$$T_{\text{eff}} = 5958 \pm 60 \text{ K} \quad (2)$$

$$\log g = 4.41 \pm 0.06 \quad (3)$$

$$[\text{Fe}/\text{H}] = 0.07 \pm 0.06 \quad (4)$$

Find the relevant lines of `inlist_astero_search_controls` to specify these target values and their uncertainties, and to include them in χ^2_{spectro} .

- `chi2_seismo_fraction` is currently set so that the total χ^2 is an average of χ^2_{spectro} and χ^2_{seismo} . Change it so that $\chi^2 = \chi^2_{\text{spectro}}$.
- Decide on which parameters to vary. You need to choose from mass, initial metallicity, initial helium abundance, mixing length parameter and the overshooting parameter. You can also restrict the initial helium abundance to be a linear function of the metallicity (i.e. to specify an *enrichment law*). Modify the controls `vary_*` to reflect your choice.

¹This fixes a minor bug that prevents us adding data to the history files later.

- Choose initial guesses, lower bounds and upper bounds for *all* the parameters that can vary, even if you aren't varying them. (e.g. even if you aren't using `f_ov`, you need to specify the value that will be used.) Specify these initial guesses with the `first_*`, `min_*` and `max_*` controls.

2 Running

With every new `astero` run, I highly recommend setting the `search_type` to `'use_first_values'` for testing. First make sure you can get one run to work before you spend time fitting the model!

- Make sure the line `search_type = 'use_first_values'` is uncommented and comment any other lines starting with `search_type`.
- Compile and run! (`./clean`, `./mk`, `./rn`!)

Take note of the terminal output as there are a few extra lines that tell you how the fit is progressing. I generally run MESA by piping to `tee`, which saves the terminal output to a file at the same time as it's shown on screen. i.e. I run something like `./rn |& tee log.txt` (which also saves the error output to `log.txt`).

Assuming your run of a single track works, you can now choose one of the optimisation methods to start fitting the model. Note the `*_results.data` file that is created and updated while the fit is happening.

3 Plotting

Once you've got the run going, let's use PGSTAR to see how well we're fitting the data in the HR diagram.

- Switch on PGSTAR in `inlist_astero`.
- With the defaults as a guide, edit `inlist_pgstar` to add an HR diagram plot with appropriate axis limits.
- Set `show_HR_target_box = .true.` and use the `HR_target_*` controls to set up the target box as you like.