SSE Assignment Problem Class

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What do we expect?

- Write a short essay/report comparing the evolution of a 1 solar mass star and a 2 solar mass star using the results from the stellar evolution code MESA.
- A page limit (not including references) of 6 pages with a font size of 12pt.
- Deadline: 4th of May 2023 at 09:00 – **HARD DEADLINE** (cannot be extended). You must submit the report to be allowed to re-submit in case of a failing grade.
- How to submit: send your report via email to all the TAs
- Recommendation: work in pairs

What should you include in the report?

1. Introduction

2. Methods: This section must only contain one paragraph. A precise description of the code is not required.

3. Results: In this section, you must present the eight plots (four for each star) and describe them without interpretation.

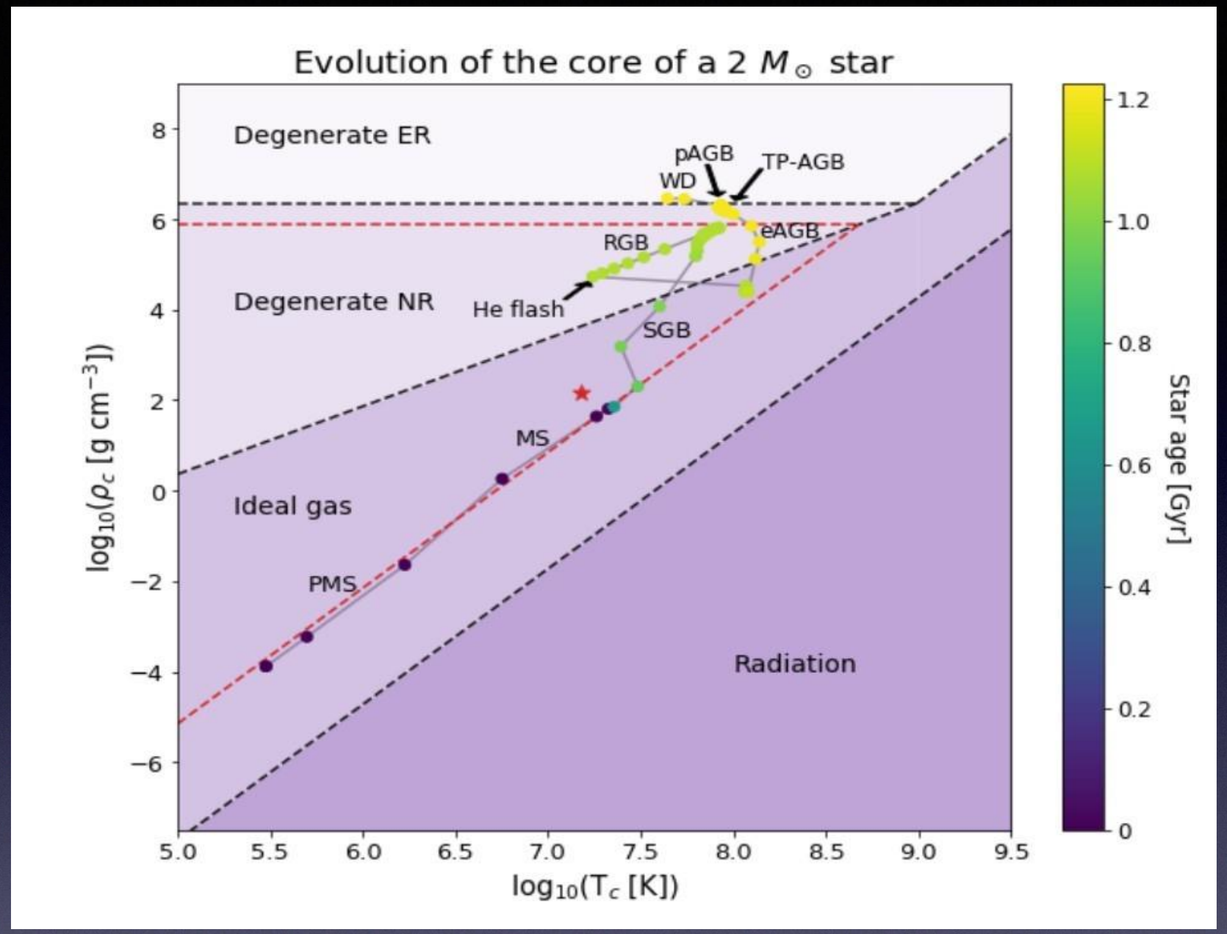
4. Discussion: This section is the most important. It must contain one subsection for each evolutionary stage of the stars. In each subsection, you must explain physically and in detail the evolution of the stars and compare them based on the eight plots.

5. Conclusion

What Plots do we expect?

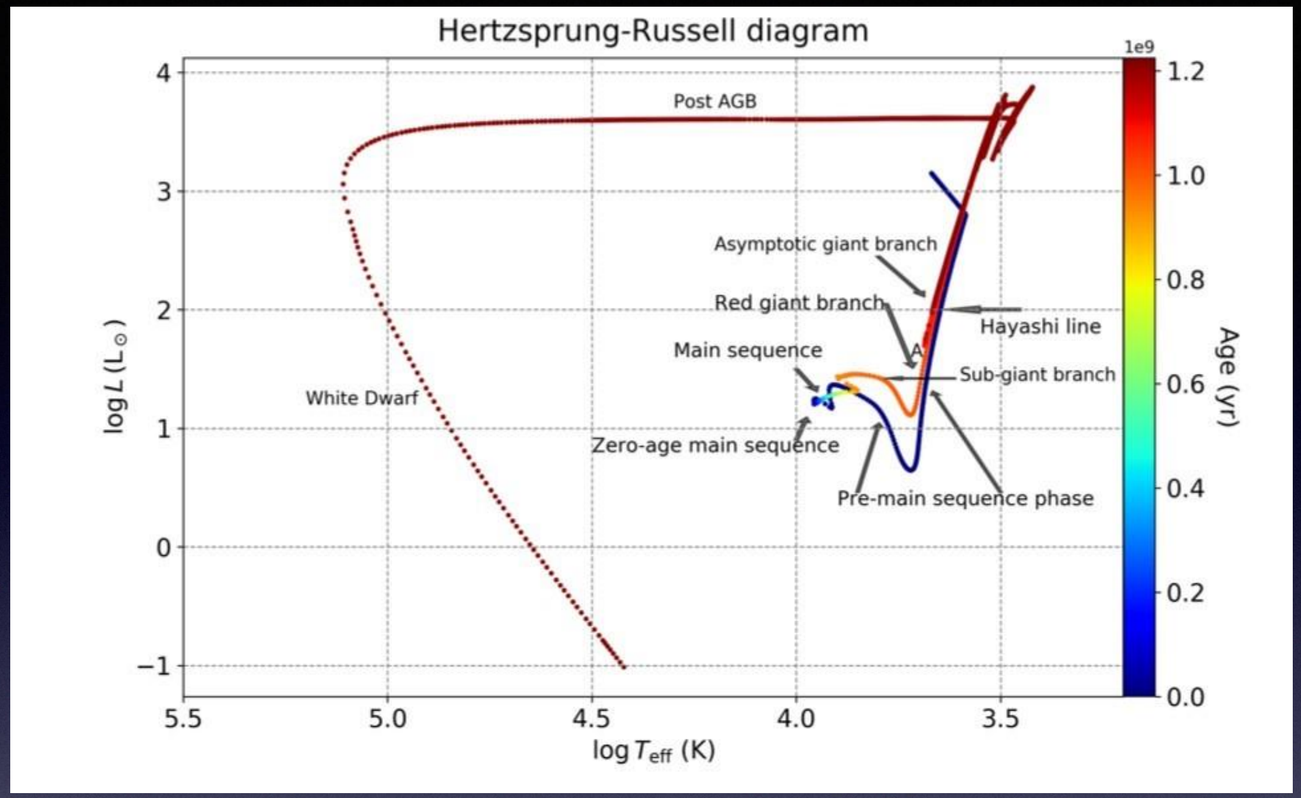
For each star:

- Evolution of the core in the log T_c – log ρ_c plane
- Hertzsprung-Russel diagram
- Convection in the pre-main sequence phase
- Convection in the main sequence phase



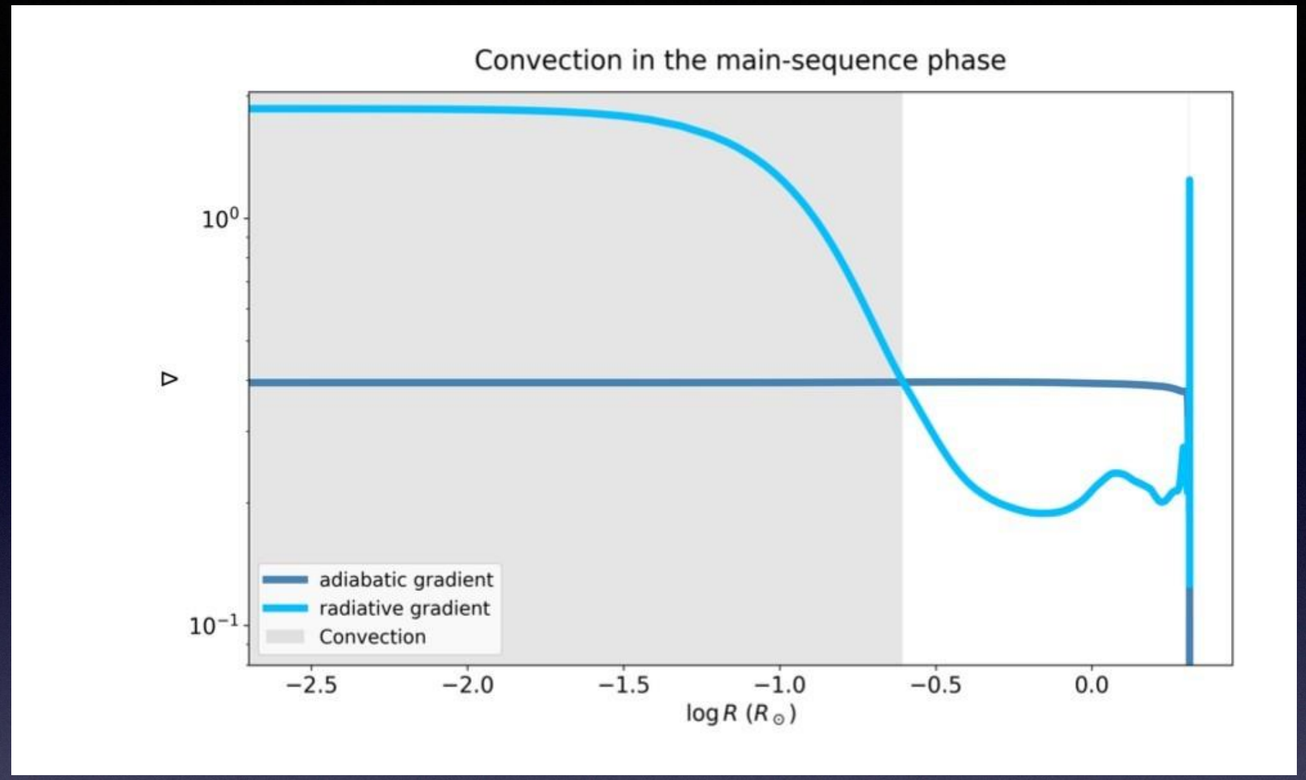
- Label the evolutionary stages.
- Indicate the age of the star at different places.
- Indicate the regions of the log Tc – log ρc plane corresponding to the four different equations of states. Derive the equations delimiting these different zones.
- Add the theoretical evolutionary track of a 1/2 Msun star in the log Tc – logρc plane.
- Mark the current position of the solar core on the 1 Msun plot.
- Make sure to include any equations you use/derive in your report!

Evolution of the core in the log Tc – log ρc plane



- Using the output files created during the simulation, plot the evolution of the star in the Hertzsprung-Russell diagram, that is in the log Teff – logL plane where Teff is the effective temperature and L the luminosity of the star.
- Label the evolutionary stages.
- Indicate the age of the stars at different places.

Hertzsprung-Russel Diagram



- Plot the adiabatic and radiative gradients as a function of radius when the star is in the pre main sequence AND main sequence phase. You only need to make use of a single profile#.data file. However, this file has to correspond to the main sequence or pre-main sequence phase.
- Show the regions where convection occurs.

Convection in the PMS and MS

How do I manipulate the MESA outputs?

- Python is recommended.
- Use the mesa_reader python package, will make your life a lot easier!
- The LOGS files produced by MESA are split into: profiles which contain properties of the star at various ages in its evolution, and history.data which contains global properties across the entire simulation of the star (such as luminosity and effective temperature)

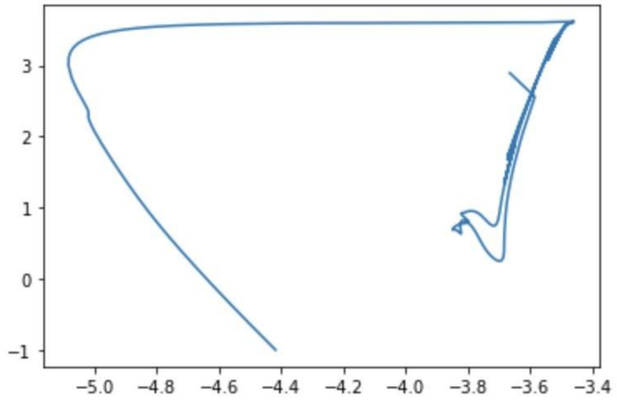
MESA Profiles

- Split into columns of the various properties of the star at various ages in its lifetime.
- Using mesa_reader these columns can be isolated into arrays that can be manipulated
- Examples of key column names you will care about are: logT, logRho, LogR, grada and gradr.

Example of H-R diagram

- Only requires 4 lines in python to make a basic H-R diagram, of course see the assignment document for the additional information we require from you.

```
In [1]: import mesa_reader as mr
        import matplotlib.pyplot as plt

In [3]: h = mr.MesaData('history.data')
        plt.plot(-h.log_Teff, h.log_L)

Out[3]: [<matplotlib.lines.Line2D at 0x1192f5190>]
```



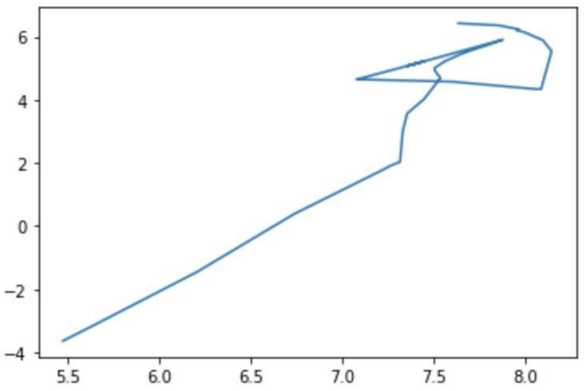
Example of Creating Tc vs Rho_c Plot

In [1]:
```
import mesa_reader as mr
import matplotlib.pyplot as plt
```

In [45]:
```
l = mr.MesaLogDir('./LOGS')
Prof_nums=l.profile_numbers

Central_Ts=[]
Central_Rhos=[]
for Prof in Prof_nums:

    n=l.profile_data(profile_number=Prof)
    Central_T=n.logT[-1]
    Central_Rho=n.logRho[-1]

    Central_Rhos.append(Central_Rho)
    Central_Ts.append(Central_T)
    #print(n.logT[-1])
```

In [46]:
```
plt.plot(Central_Ts,Central_Rhos)
```

Out[46]:
```
[<matplotlib.lines.Line2D at 0x117600d60>]
```



Convective Plots

In [4]:
```
l = mr.MesaLogDir('./LOGS')
Prof_nums=l.profile_numbers

Central_Ts=[]
Central_Rhos=[]

n=l.profile_data(profile_number=50)
grad_R=n.gradr
grad_A=n.grada
radius=n.radius


#print(n.logT[-1])
```

In [7]:
```
plt.plot(radius,grad_R)
plt.plot(radius,grad_A)
```

Out[7]: [<matplotlib.lines.Line2D at 0x11e0febb0>]