Questions

1. What effect does including the MESA EoS have on the results of a CE simulation?

2. What effect does recombination, specifically, have on the results?

3. What effect does convection, specifically, have on the results?

4. How are the answers affected when going from RGB to AGB case?

Proposed plan for paper

0. Understand EoS and initial stellar profile.

1. Improved fiducial RGB run.

2. As (1) but with MESA EoS (implicitly injects recombination energy locally).

3. As (2) but continuously **remove** released recombination energy (simulates it being radiated away).

4. Evolve single star on grid, with a focus on modeling convection.

5. Rerun RGB cases 1-2-3 but now with evolved single star.

6. Redo for AGB case

Proposed plan for paper

Model	Name	Number	Comment
R0	Old fiducial RGB	143	already done
R1	New fiducial ideal EoS RGB	—	
R2	MESA EoS	—	
R3	MESA EoS but remove released recombination energy	—	
R1*	Ideal EoS with initial condition from single star run	—	less crucial
R2*	Like R2 but initial condition from single star run	—	
R3*	Like R3 but initial condition from single star run	—	
A1	Old fiducial AGB run	183	already done
A2/A2*	As R2 or R2* but with AGB	—	choose one or the other
A3/A3*	As R3 or R3* but with AGB	—	optional

Step 0

Understand the MESA tabular EoS and its ramifications for the initial RGB stellar profile (in progress).

- Plot EoS and write up a section similar to Sec. 2.1 of Reichardt+2020 incl background and implementation into AstroBEAR. Also compare our figs with theirs as a check.

- Look at MESA initial profile carefully and analyze it for various thermodynamic properties. Compare with ideal gas case. Separate energy densities $E_{\text{internal}} = E_{\text{thermal}} + E_{\text{radiation}} + E_{\text{recombination}}$

- Make sure that AstroBEAR is accurately reproducing MESA profile outside of softening sphere.

- Repeat for AGB profile.

Step 1

Improve fiducial RGB run

- Improved resolution near particles.
- Smaller r_{soft} and keep it constant.
- Lower ambient.
- Improved refinement criteria.
- Evolve simulation for longer.
- Compare the results with Run 143 (old fiducial from the papers).
- (Leave larger initial separation, rotation and larger box for future work).

Step 2

As (1) but with MESA EoS (implicitly injects recombination energy locally). Improved resolution near particles.

- Ideally would do this step at the same time as step 1 so that we can make sure that the same numerical parameter values (e.g. resolution) are sufficient for both the runs.

- Compare the two simulations (ideal gas vs MESA EoS).

Step 3

As (2) but continuously **remove** released recombination energy (simulates it being radiated away).

- This will involve some development of the code.
- This is a new step that no one else has done.
- It will allow us to isolate the effect of recombination from that of mean molecular weight μ and adiabatic index $\gamma_1 = (d\ln P/d\ln\rho)_S$.
- Compare the two simulations (using latent recombination envery vs radiating it away).

Step 4

Evolve single star on grid, with a focus on modeling convection.

- With and without velocity damping.
- Analyze for convection.
- Try to get statistically steady state of convection.
- Compare the three cases (ideal gas, MESA EoS and MESA EoS removing recombination energy).
- may be very demanding computationally, success not guaranteed!
- will require new analysis scripts.

Step 5

Rerun RGB cases 1-2-3 but now with evolved single star.

- This is the more realistic case if we can do it (but remember that our initial conditions are not very realistic because of the initial separation).

- Comparison of these runs (call them 1*-2*-3*) with 1-2-3 will allow us to isolate the effects of convection (2* vs 2 and 3* vs 3) and relaxation (1* vs 1).

Step 6

Redo for AGB case

- Use run 183 from paper IV as the fiducial run (no need to improve it)
- Do cases 2 and 3 or, if single star runs are feasible and we got nice convection in the RGB case, can do 2* and 3* instead. At worst, do case 2 only.