

Numerical Issues on the TP-AGB

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Method of Solution

- ▣➤ All codes are supposed to do (almost) the same thing!
- ▣➤ Solve the equations of stellar structure and chemical evolution
- ▣➤ We all choose to do this in slightly different ways
- ▣➤ Does this affect the results we get?

Terminology

⇒ Timestep - $t \rightarrow t + \Delta t$

⇒ Iteration - A step toward converging the next timestep

Iteration is necessary as we are using an implicit scheme

Three methods of solution

▣▣▣▣ *Non-simultaneous*

▣▣▣▣ *Partially simultaneous*

▣▣▣▣ *Fully simultaneous*

Non-simultaneous solution

- ▣▣▣▣ Equations of structure & chemical evolution solved for separately
- ▣▣▣▣ Iterate to make structure model for next timestep
- ▣▣▣▣ Use that structure to calculate a chemical evolution timestep
- ▣▣▣▣ Examples - FRANEC, EVOL

Partially simultaneous solution

- Make one iteration on the stellar structure
- Use this structure to make one iteration on the chemical evolution
- Repeat, until you converge on a model for the next timestep
- Example - MSSSP

Fully simultaneous solution

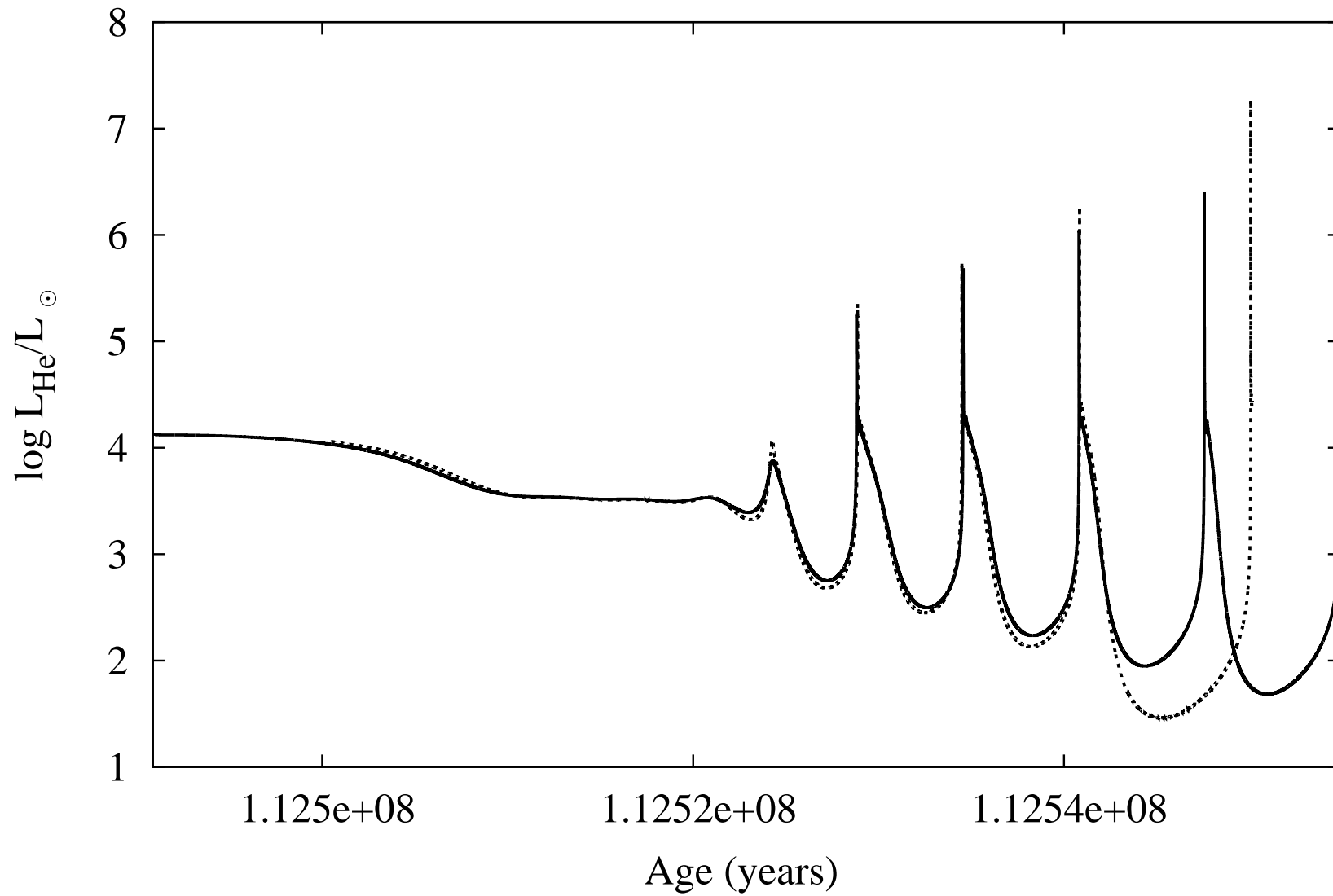
- ▣▣▣▣ Solve the equations of stellar structure *together* with the equations for chemical evolution at the same time
- ▣▣▣▣ Do this at *each* iteration of *each* timestep
- ▣▣▣▣ STARS and related codes

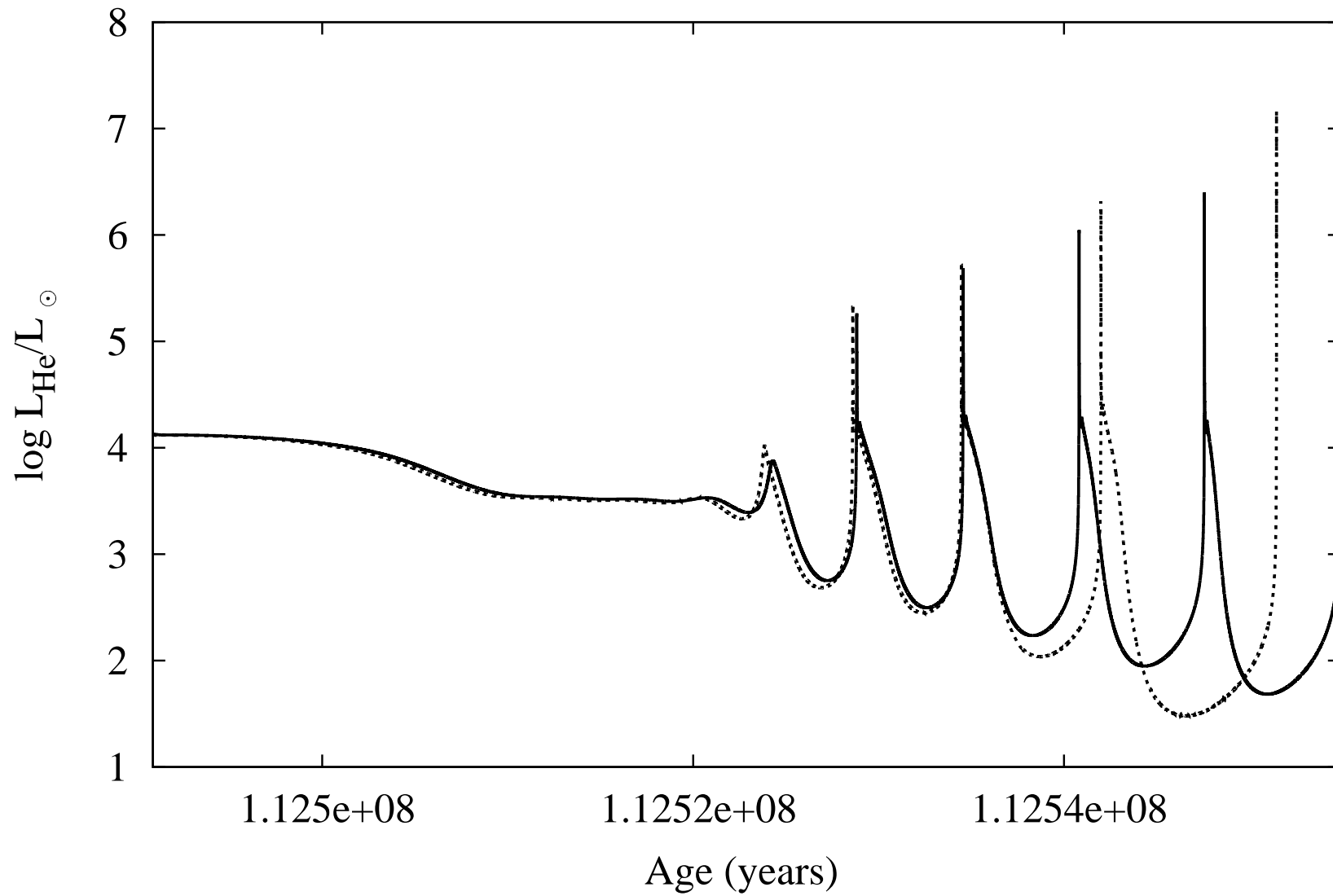
So what?

- ▣➔ It is generally believed that the method shouldn't make a difference
- ▣➔ There are some situations where it might, e.g. VLTPs
- ▣➔ No-one has ever been in a position to test it

STARS unplugged

- ▣ Use the minor isotope routines to do the mixing
- ▣ Tested on a $5 M_{\odot}$ $Z=0.02$ model
- ▣ No discernable difference prior to the TP-AGB





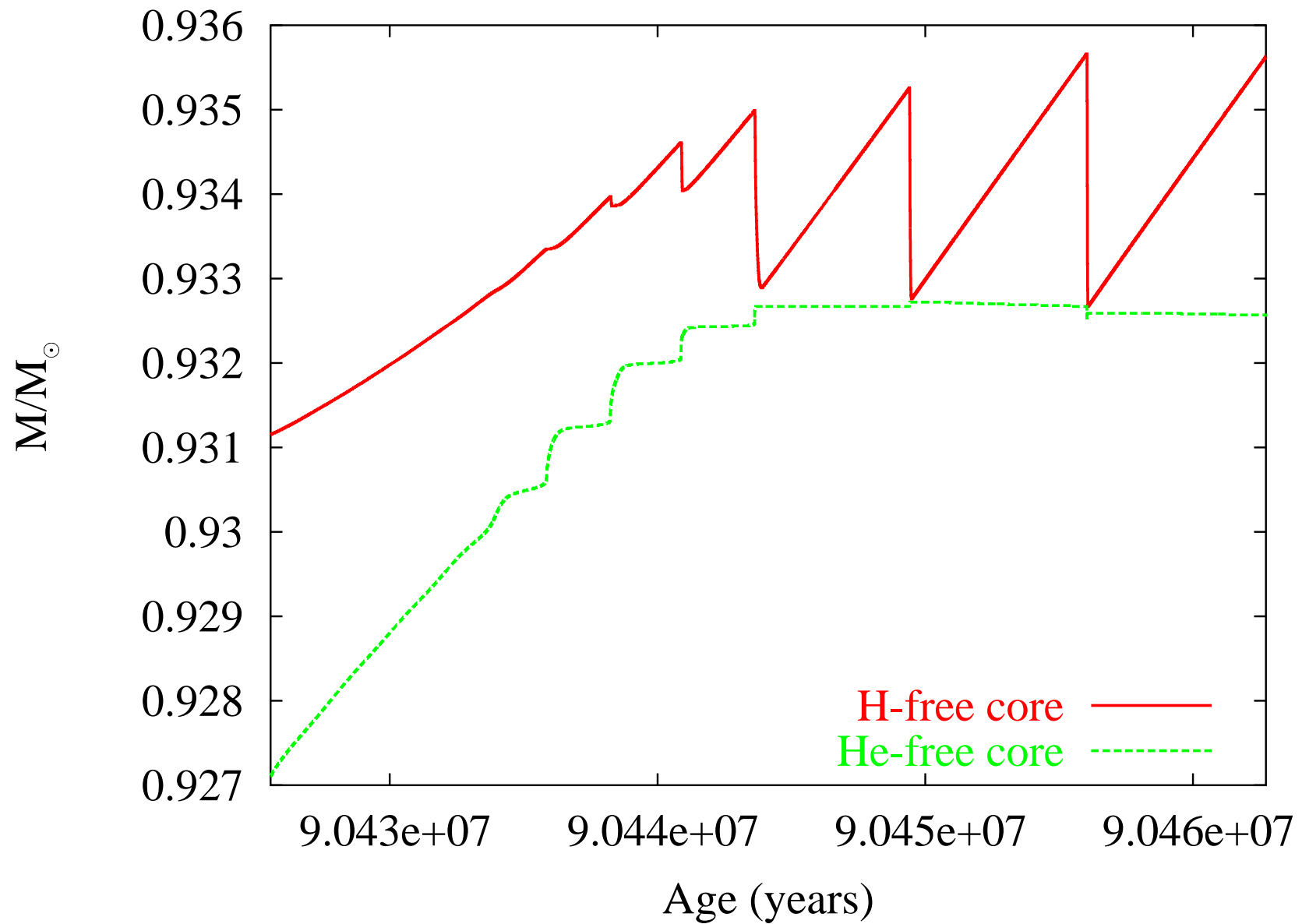
Results

- ▣▣▣▣➔ Difference in core mass, depth of TDUP less than 1%
- ▣▣▣▣➔ Models are not quite identical though
- ▣▣▣▣➔ Non-simultaneous solution seems to give longer pulse periods
- ▣▣▣▣➔ Similar story for $3 M_{\odot}$ $Z=0.02$ models

TP	M_H (M_\odot)	τ_{ip} (10^4 yr)	$\log(L_{He}^{max}/L_\odot)$	ΔM_H (M_\odot)	ΔM_{DUP} (M_\odot)	λ	C/O
1	0.55267	...	4.36792	0.01628	...	...	0.315
2	0.56894	7.60	6.27639	0.00440	...	...	0.315
3	0.57333	7.78	5.56767	0.00297	...	...	0.315
4	0.57629	8.89	6.65021	0.00580	...	...	0.315
5	0.58208	9.33	6.62750	0.00574	...	...	0.315
6	0.58781	8.81	6.80665	0.00621	0.00047	0.076	0.317
7	0.59355	8.22	6.90432	0.00633	0.00113	0.179	0.330
8	0.59875	7.76	7.03324	0.00660	0.00190	0.288	0.356
9	0.60345	7.50	7.16711	0.00701	0.00266	0.379	0.393
1	0.54981	...	5.64095	0.01704	...	...	0.315
2	0.56684	6.87	5.33562	0.00241	...	...	0.315
3	0.56925	8.99	6.45104	0.00517	...	...	0.315
4	0.57441	10.99	6.65133	0.00591	...	...	0.315
5	0.58032	10.59	6.87245	0.00642	...	...	0.315
6	0.58666	10.01	6.96026	0.00663	0.00064	0.097	0.318
7	0.59265	9.52	7.12672	0.00707	0.00142	0.201	0.328
8	0.59830	9.17	7.28263	0.00755	0.00222	0.294	0.347

Any salvation?

- ▣➤ Have I been wasting my time for the last few years?
- ▣➤ Two situations where simultaneous solution might be important
 - Hot TDUP (Herwig 2004)
 - very late thermal pulses



Conclusions

- Fully simultaneous solution doesn't seem to give inherently different results
- Some divergence does occur - the reason is unclear
- Need to find another explanation as to why predictions differ...