Modeling Evolution and Pulsation of Classical Cepheids

Oliwia Ziółkowska

supervisor: Radek Smolec

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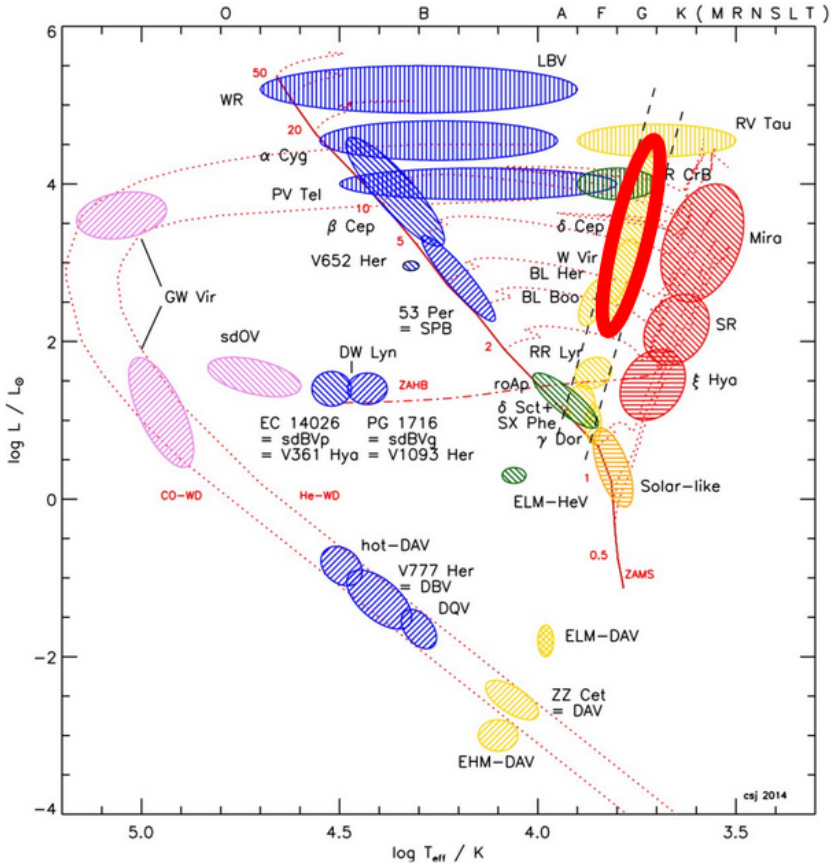
Classical Cepheids



Properties:

- ⋆ Yellow supergiants of 3–15 $M_\odot$
- ⋆ High-amplitude radial pulsations on the classical instability strip due to κ mechanism

Problems:

- ⋆ Mass discrepancy – evolutionary mass ∼ 10 % too high
- ⋆ Additional variability – nonradial modes?
- ⋆ Non-pulsators inside the Instability Strip

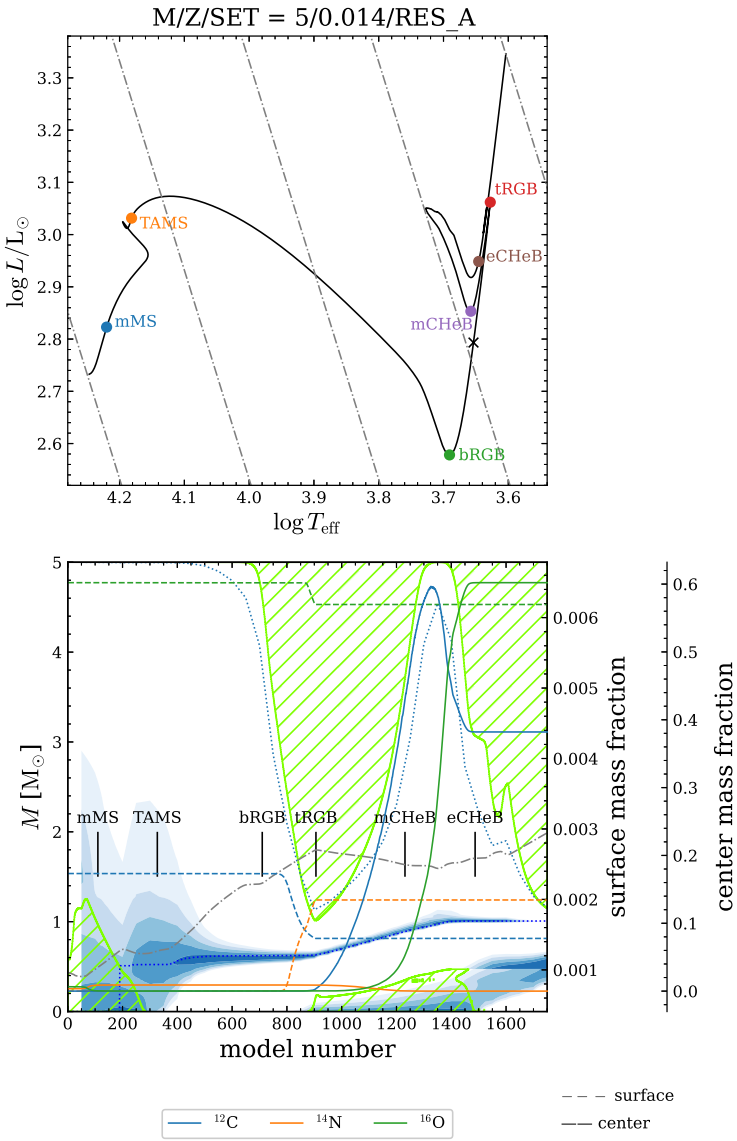
Uncertainties of Evolutionary Models

How to make evolutionary mass lower:

- ⋆ Pulsation-driven mass loss
- ⋆ Rotational mixing
- ⋆ Convective core overshooting

But, additionally evolutionary calculations have a lot of uncertainty:

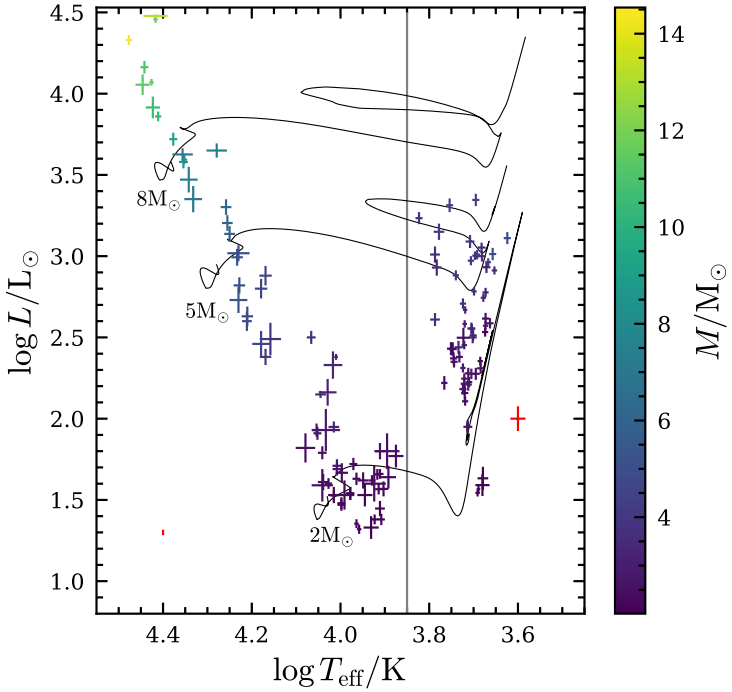
- ⋆ Convection
- ⋆ Atmosphere
- ⋆ Reference solar composition (what goes into Z)
- ⋆ Reaction rates, and more...



We studied those in two papers using MESA

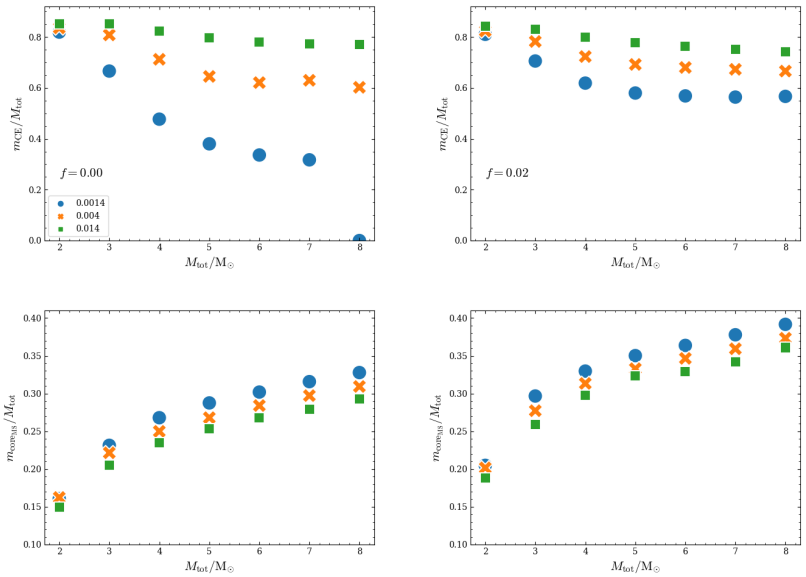
Uncertainties of Evolutionary Models

- ⋆ Paper I – log L, log T_{eff}, age



- ⋆ Results used e.g. for tracks and P-age, M-L relations
- ⋆ Signifact uncertainties for evolved stars

- ⋆ Paper II – abundances of H, He, C, N, O, Ne, Mg, and C/O ratio



- ⋆ Published in January 2026
- ⋆ Depth of the convective envelope sensitive to modeling
- ⋆ Abundances in general much more robust outcome than L, T_{eff}

Cepheids in Eclipsing Binaries*

* work in progress

name	P (d)	M ($M_\odot$)	q	R ($R_\odot$)	$T_{\rm eff}$ (K)	$\log L$ ($L_\odot$)	mode
OGLE-LMC-CEP-0227	3.797086	4.15 ± 0.03	0.979 ± 0.003	34.87 ± 0.12	6000 ± 160	3.15 ± 0.05	F
		4.06 ± 0.03		44.79 ± 0.014	5100 ± 120	3.09 ± 0.04	
*OGLE-LMC-CEP-4506	2.987846	3.61 ± 0.03	0.975 ± 0.003	28.5 ± 0.2	6120 ± 160	3.01 ± 0.05	F
		3.52 ± 0.03		26.4 ± 0.2	6070 ± 150	2.93 ± 0.05	
OGLE-LMC-CEP-2532	2.035349	3.98 ± 0.10	0.992 ± 0.012	29.2 ± 1.4	6350 ± 150	3.10 ± 0.06	1O
		3.94 ± 0.09		38.1 ± 1.8	4800 ± 220	2.84 ± 0.09	
OGLE-LMC-CEP-1718B	2.480917	4.22 ± 0.04	0.988 ± 0.005	33.1 ± 1.3	6270 ± 160	3.18 ± 0.06	1O
OGLE-LMC-CEP-1718A	1.963663	4.27 ± 0.04		27.8 ± 1.2	6310 ± 150	3.04 ± 0.06	1O
OGLE-LMC-CEP-1812	1.312903	3.76 ± 0.03	0.696 ± 0.003	17.85 ± 0.13	6120 ± 150	2.61 ± 0.04	F
		2.62 ± 0.02		11.83 ± 0.08	5170 ± 120	1.95 ± 0.04	

- ⋆ Very precise parameters from Pilecki et al. (2018) – Testing evolution models
- ⋆ We calculate the evolutionary models, with varying Z, and overshooting
- ⋆ We calculate periods along the tracks with nonlinear period corrections
- ⋆ We find the best solutions for companion and Cepheid; they should have the same age
- ⋆ We will include MESA uncertainties in our χ^2