

Theoretical predictions concerning the first dredge-up

Presenter: Kaili Cao

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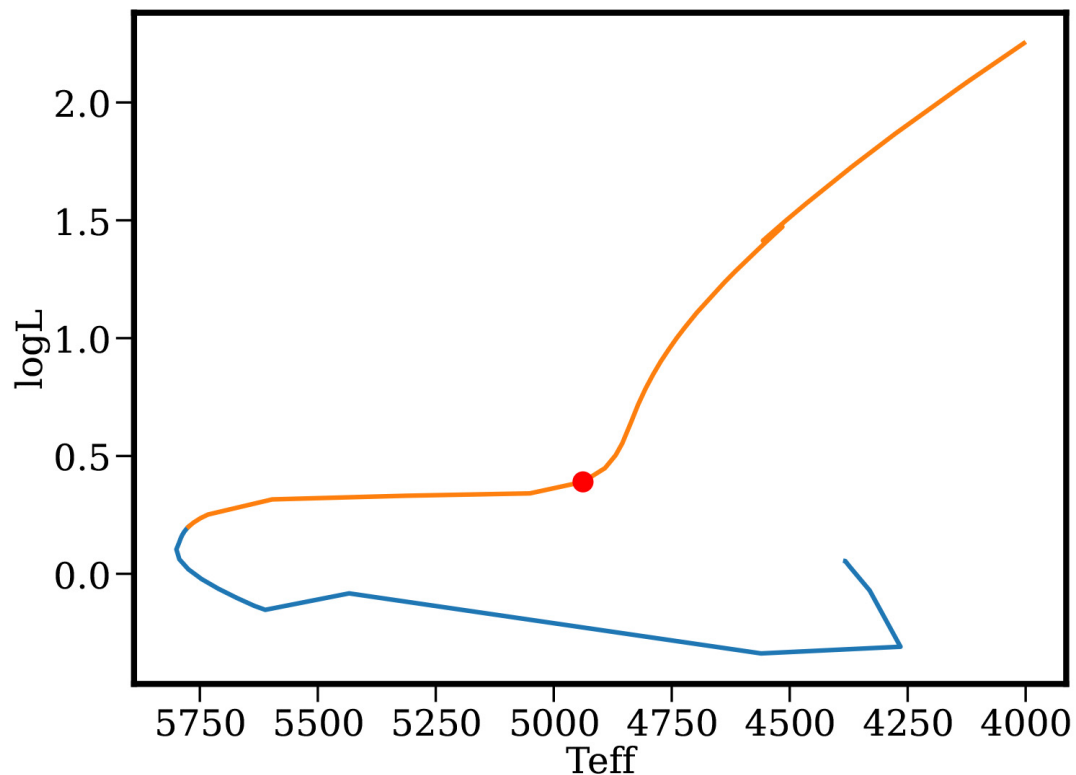
Image credit: ESO/S. Steinhöfel

Outline

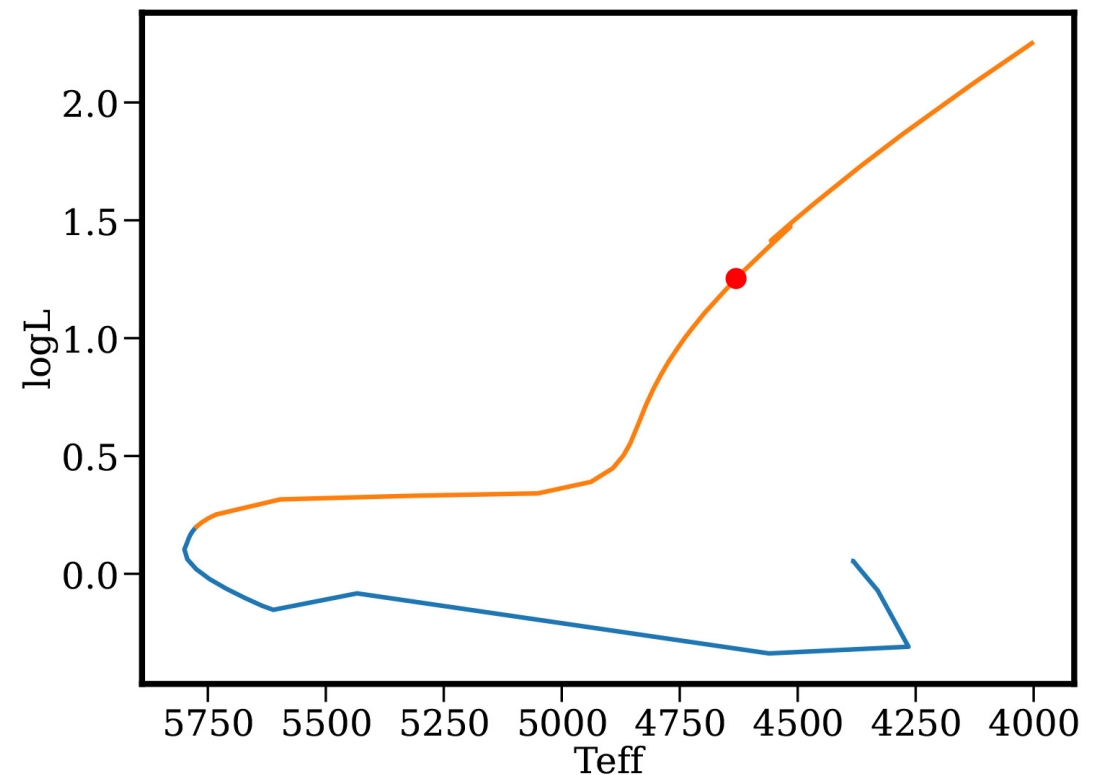
- What is the first dredge-up?
 - Interactive questions: How old is our Sun? In the series of star portraits in the background image, which one represents the current Sun?
 - What happens after the main sequence stage?
- How do we make theoretical predictions?
 - Equations of stellar structure and evolution
 - Modules for Experiments in Stellar Astrophysics (MESA)
- What have I done during the summer?
 - Initial composition and mixing length calibrations
 - Comparisons between MESA predictions and APOKASC data

What happens after the main sequence?

Before the first dredge-up

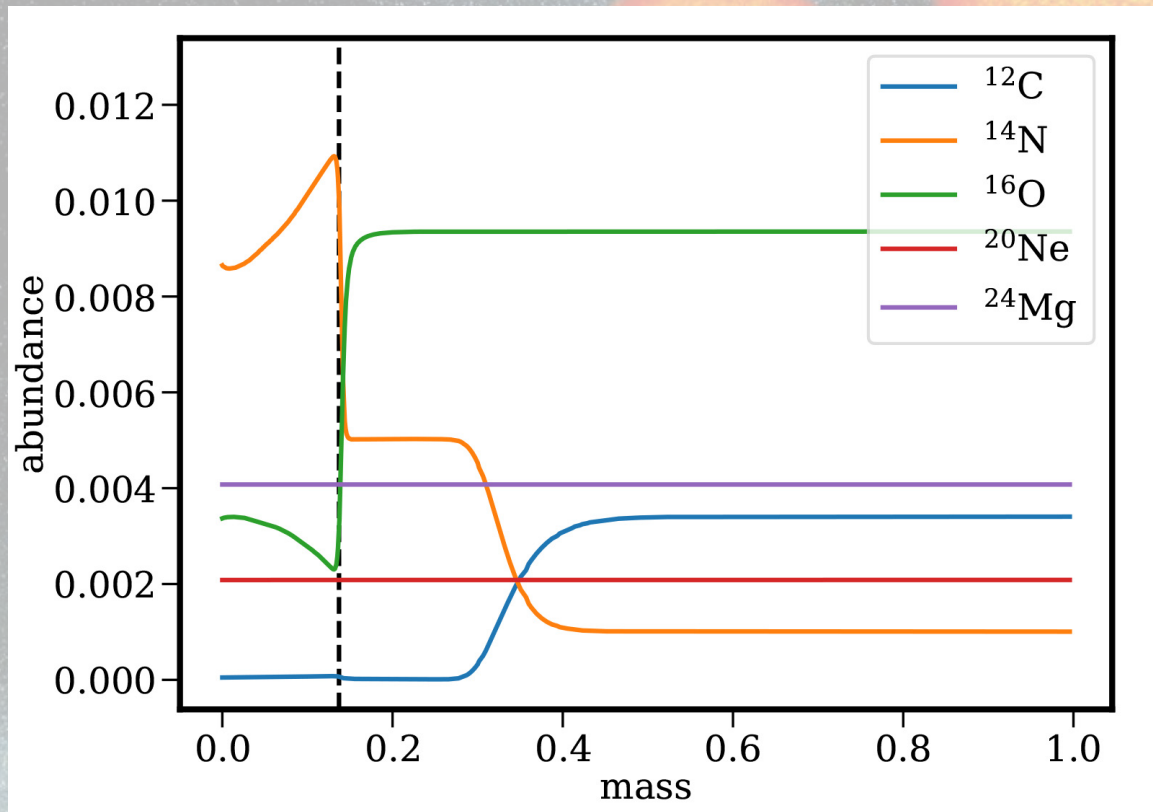


After the first dredge-up

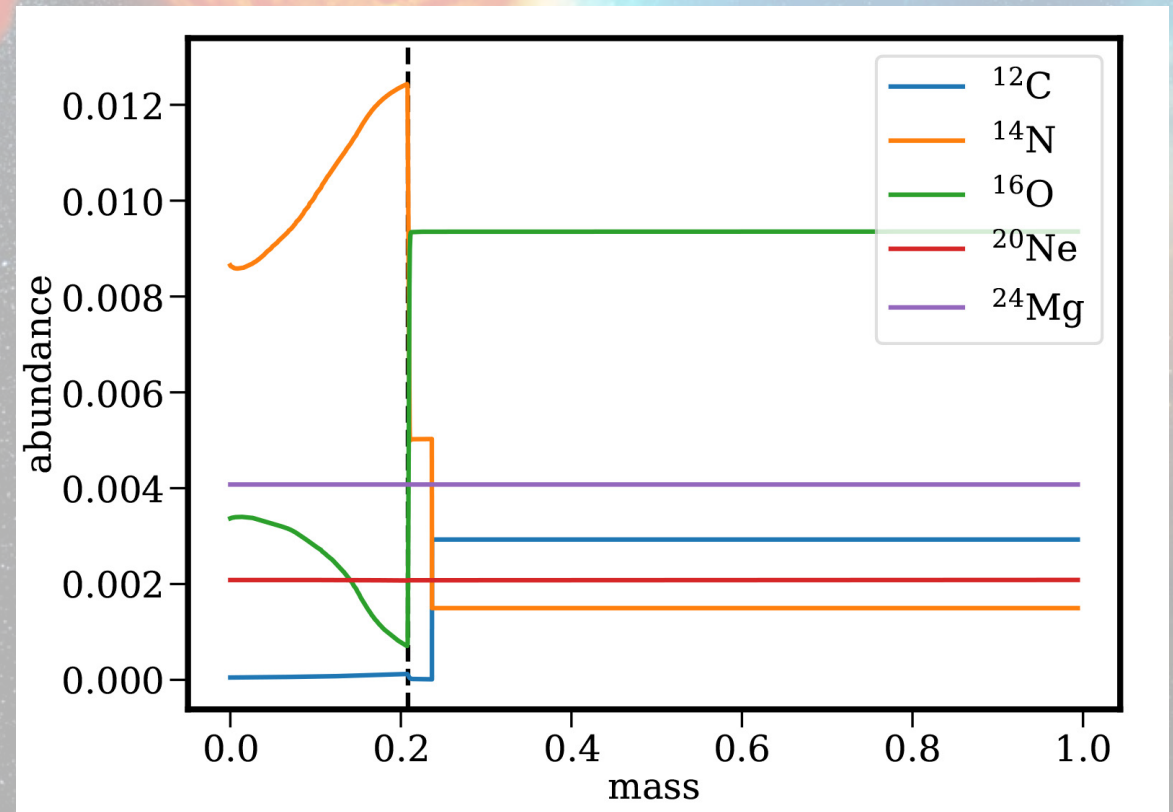


What happens after the main sequence?

Before the first dredge-up



After the first dredge-up



How do we make theoretical predictions?

- Equations of stellar structure and evolution
 - Kippenhahn R., Weigert A., Weiss A., 2013, Stellar structure and evolution
- Modules for Experiments in Stellar Astrophysics (MESA)
 - an open-source 1D stellar evolution code
 - Paxton et al. 2011, 2013, 2015, 2018, 2019

$$\frac{\partial r}{\partial m} = \frac{1}{4\pi r^2 \varrho} , \quad (10.1)$$

$$\frac{\partial P}{\partial m} = -\frac{Gm}{4\pi r^4} , \quad (10.2)$$

$$\frac{\partial l}{\partial m} = \varepsilon_n - \varepsilon_v - c_P \frac{\partial T}{\partial t} + \frac{\delta}{\varrho} \frac{\partial P}{\partial t} , \quad (10.3)$$

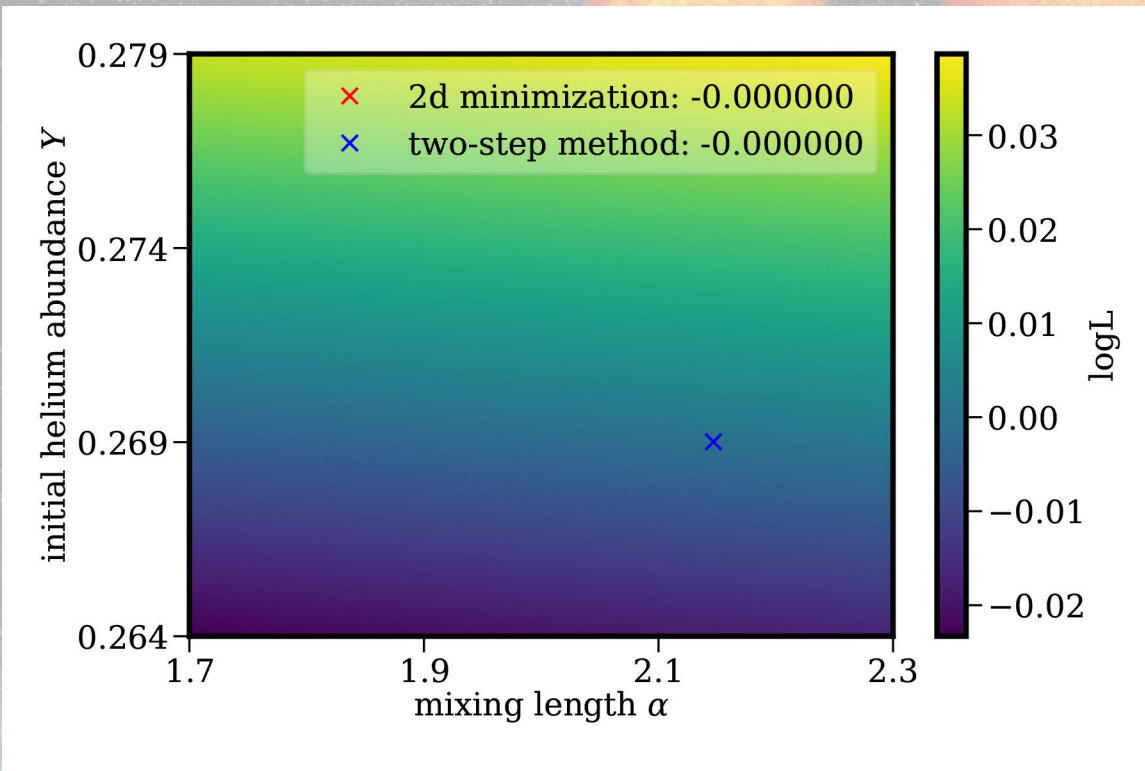
$$\frac{\partial T}{\partial m} = -\frac{GmT}{4\pi r^4 P} \nabla , \quad (10.4)$$

$$\frac{\partial X_i}{\partial t} = \frac{m_i}{\varrho} \left(\sum_j r_{ji} - \sum_k r_{ik} \right) , \quad i = 1, \dots, I . \quad (10.5)$$

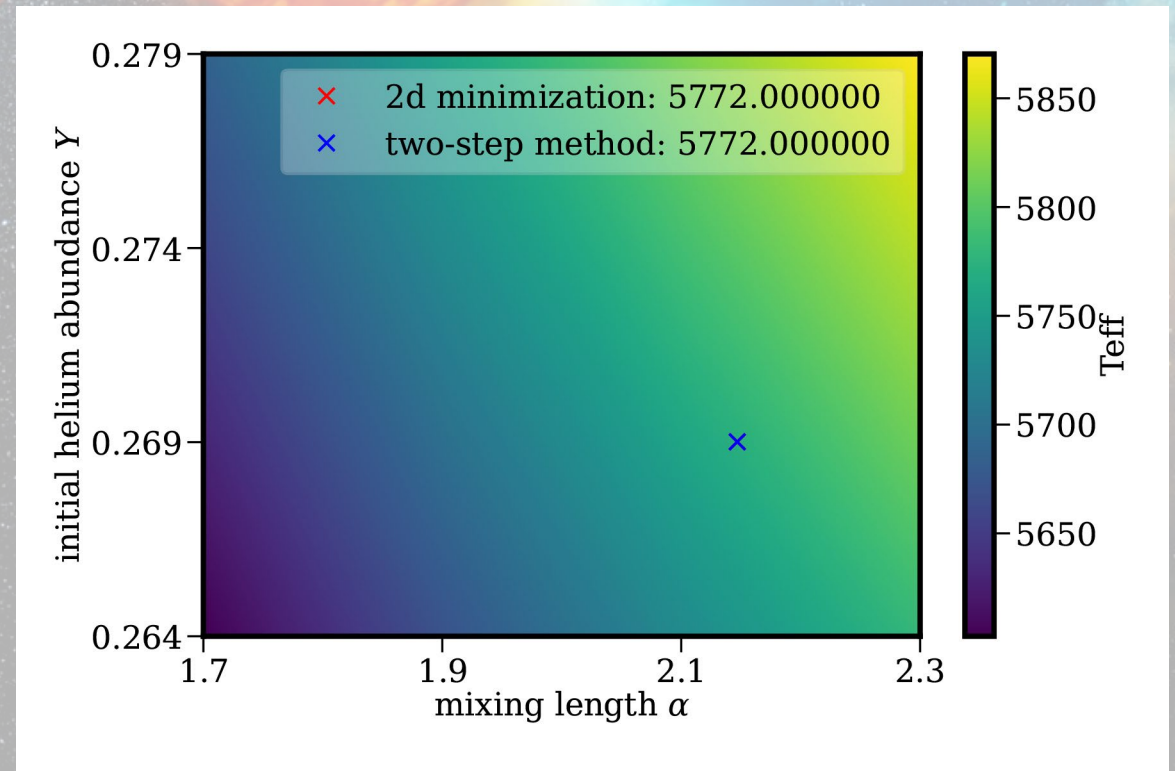
MESA

Initial composition calibration

Luminosity



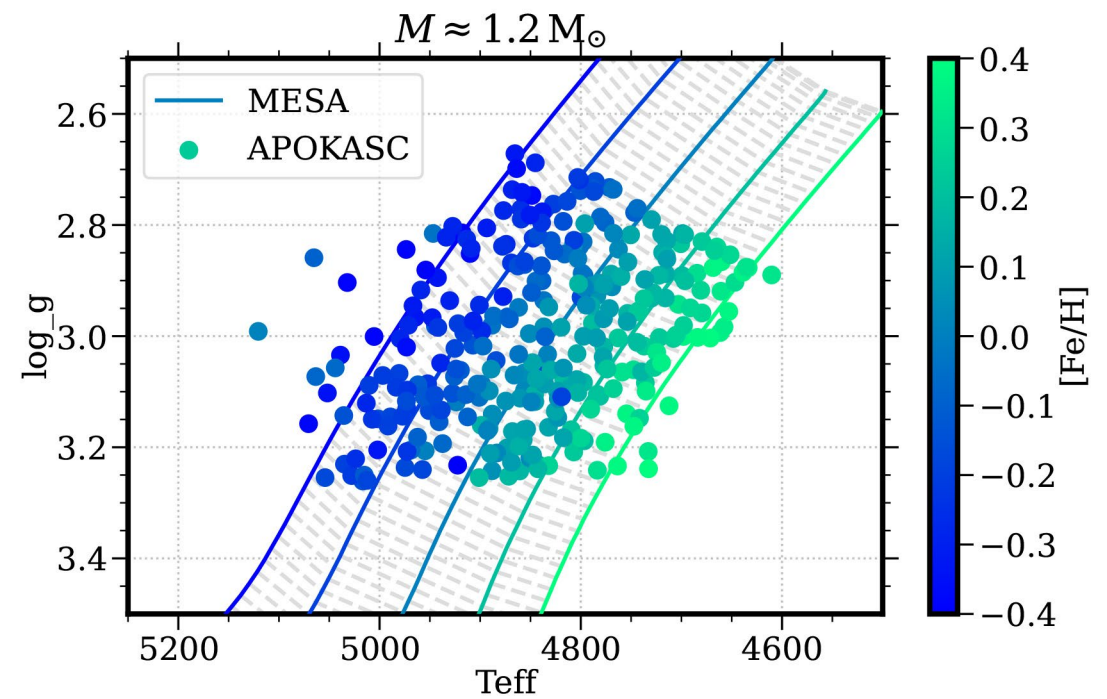
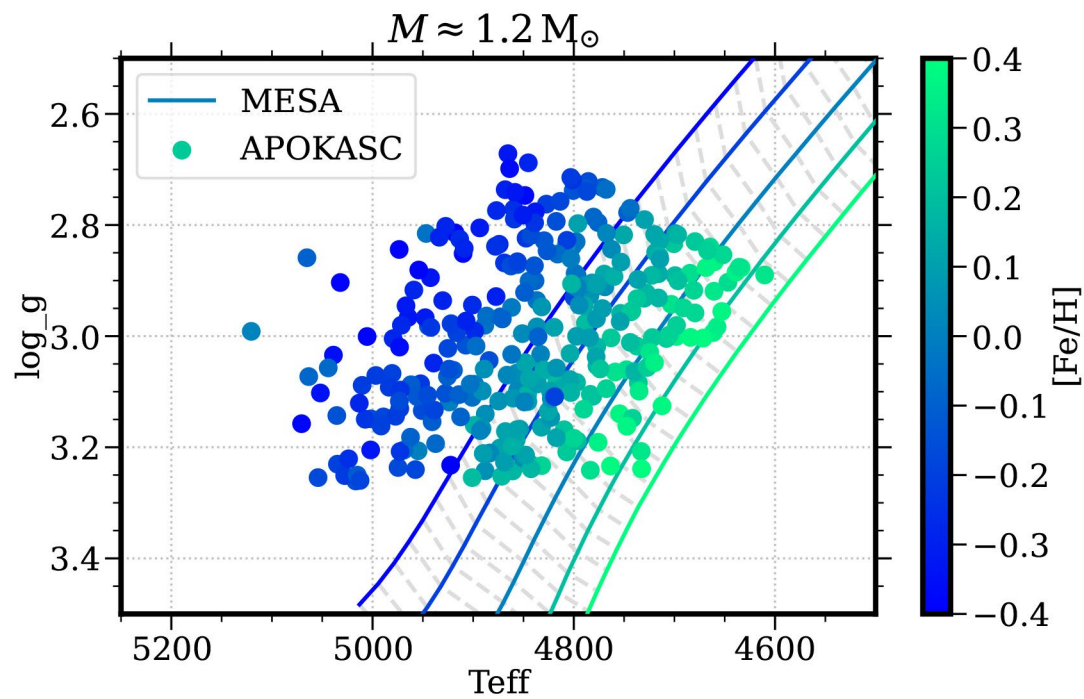
Effective temperature



Mixing length calibration

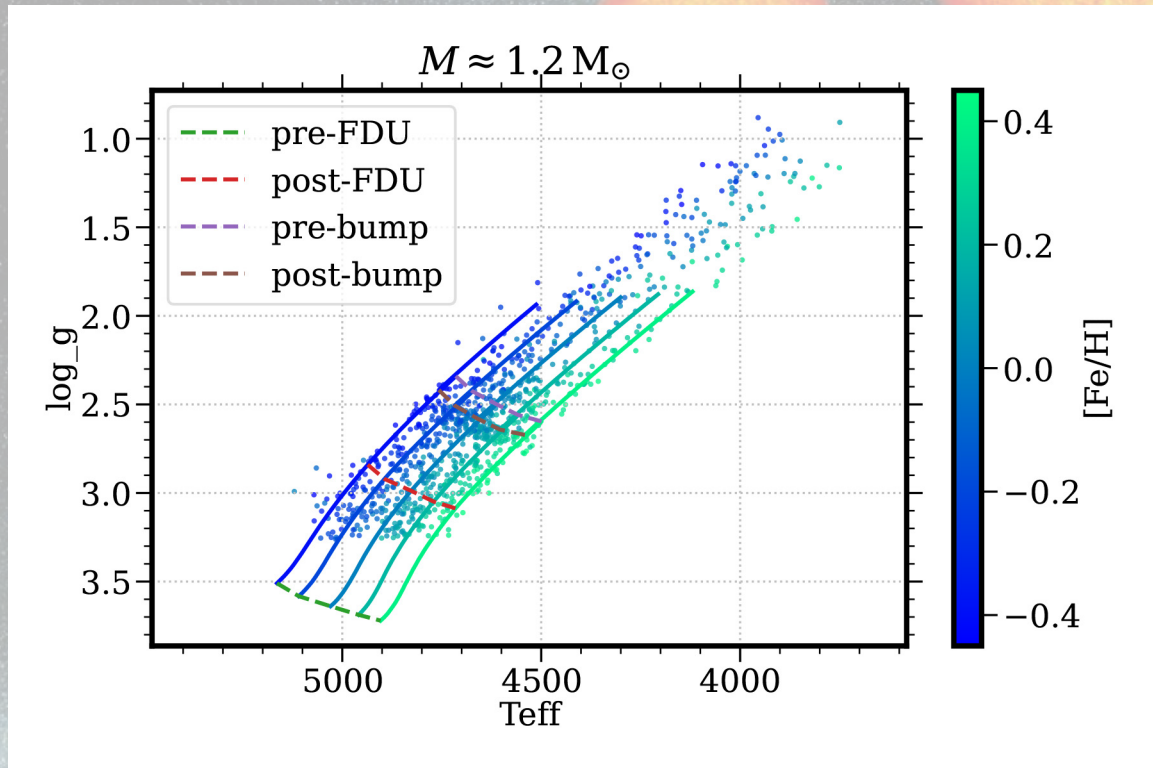
Without proper mixing length

With proper mixing length

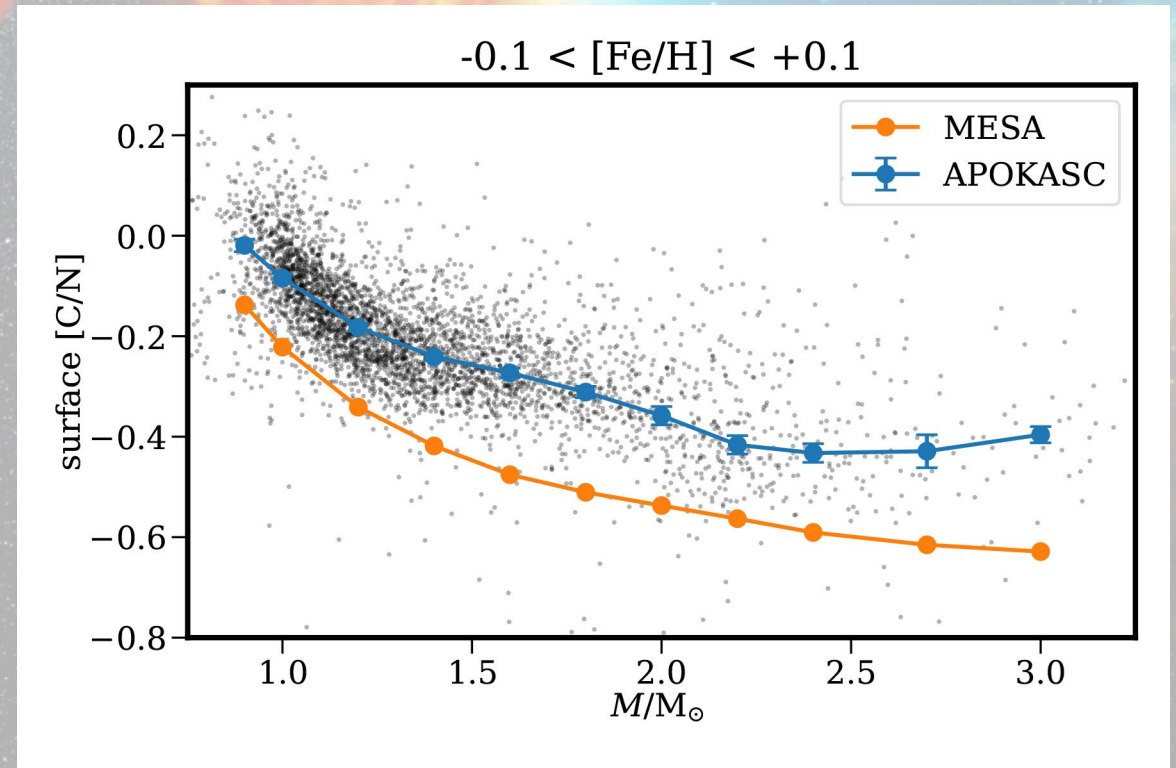


Comparisons between MESA and APOKASC

RGB bump location



Surface Carbon/Nitrogen ratio





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