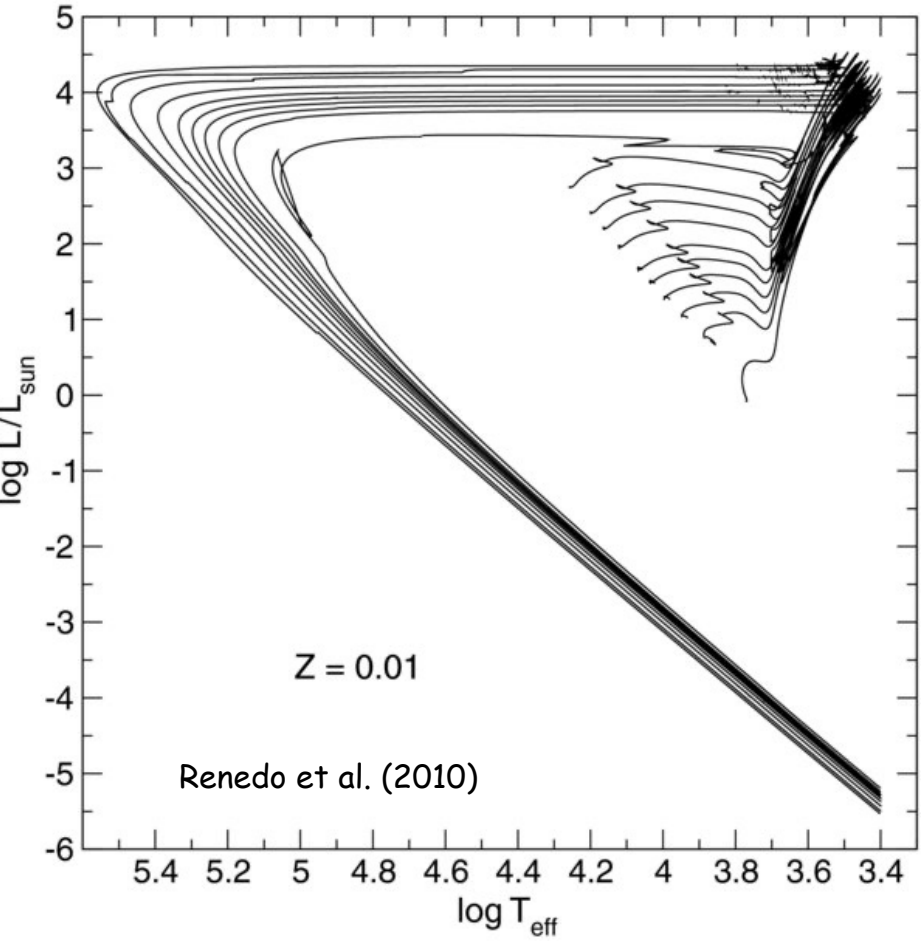
STELLAR EVOLUTION AND ITS IMPACT ON THE PROPERTIES OF WHITE DWARFS

Maurizio Salaris

Astrophysics Research Institute
LIVERPOOL JOHN MOORES UNIVERSITY

White Dwarfs

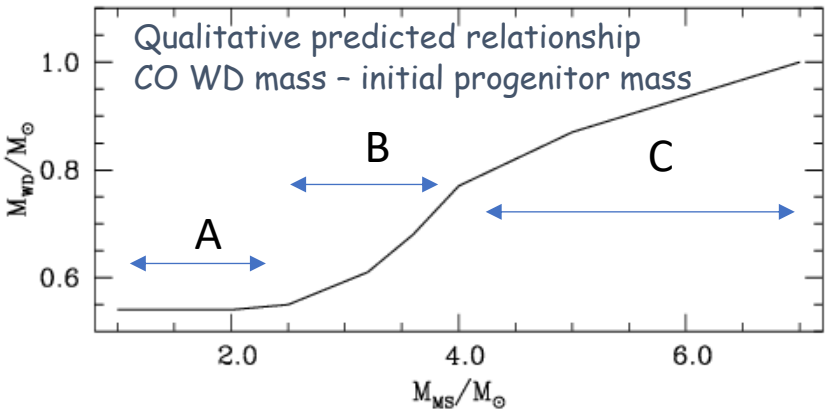


$M_{prog} < 0.5\ M_{\odot}$ → He-core WD

$0.5\ M_{\odot} < M_{prog} < 6\text{-}7\ M_{\odot}$ → CO-core WD

$6\text{-}7\ M_{\odot} < M_{prog} < 8\text{-}10 M_{\odot}$ → ONe-core WD

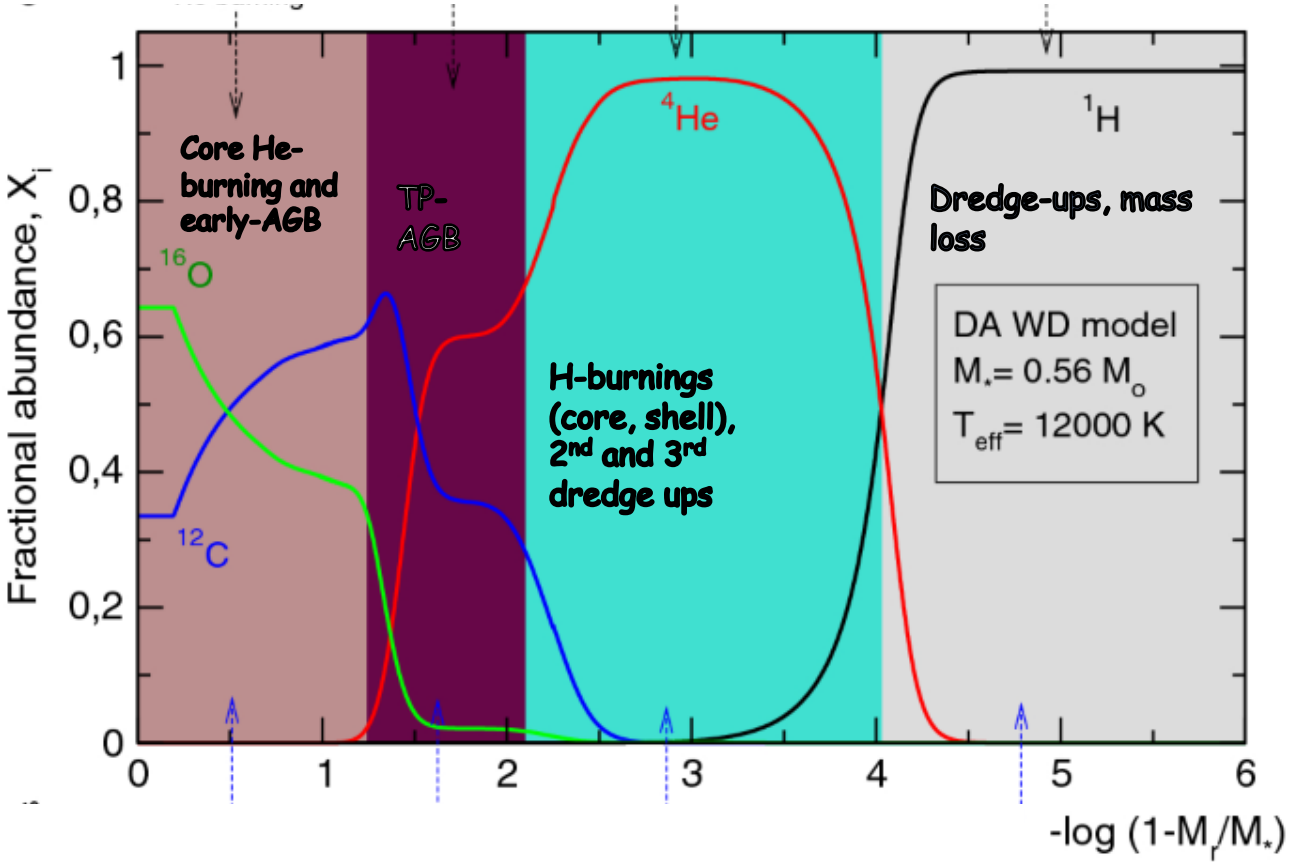
The most common type is made of CO cores

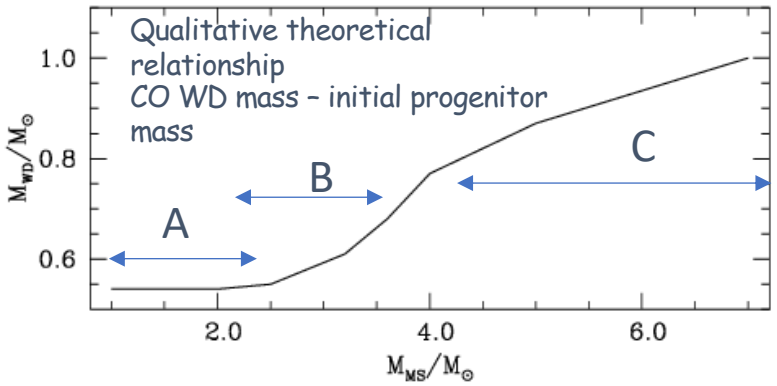


Adapted from Corsico et al. (2019)

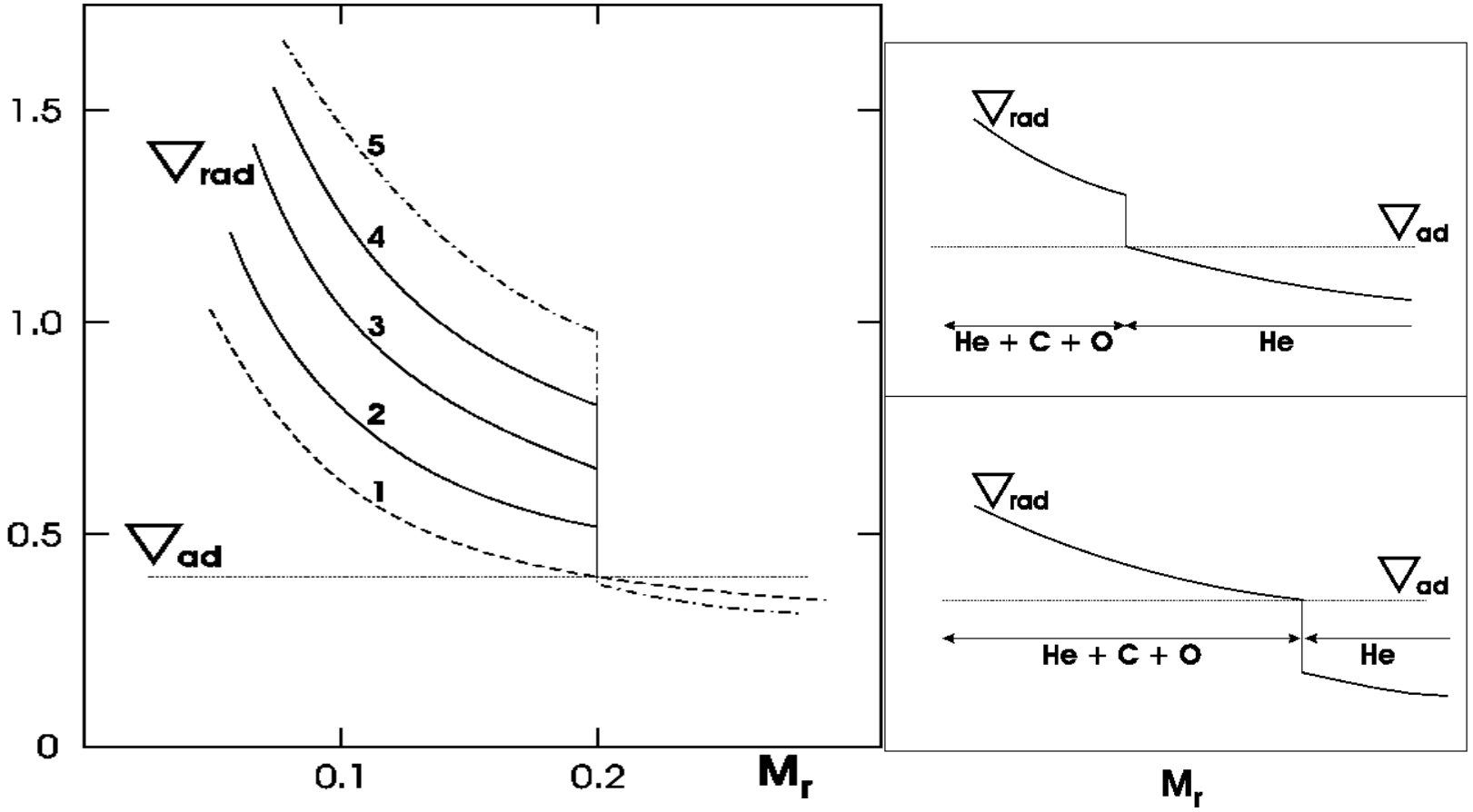
The mass of the H-exhausted core at He-burning ignition determines the innermost CO stratification

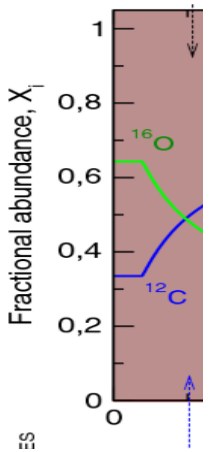
The mass increase of the H-exhausted core during early-AGB and TP-AGB essentially determines the final WD mass (interplay mass loss law, 2nd and 3rd dredge ups)



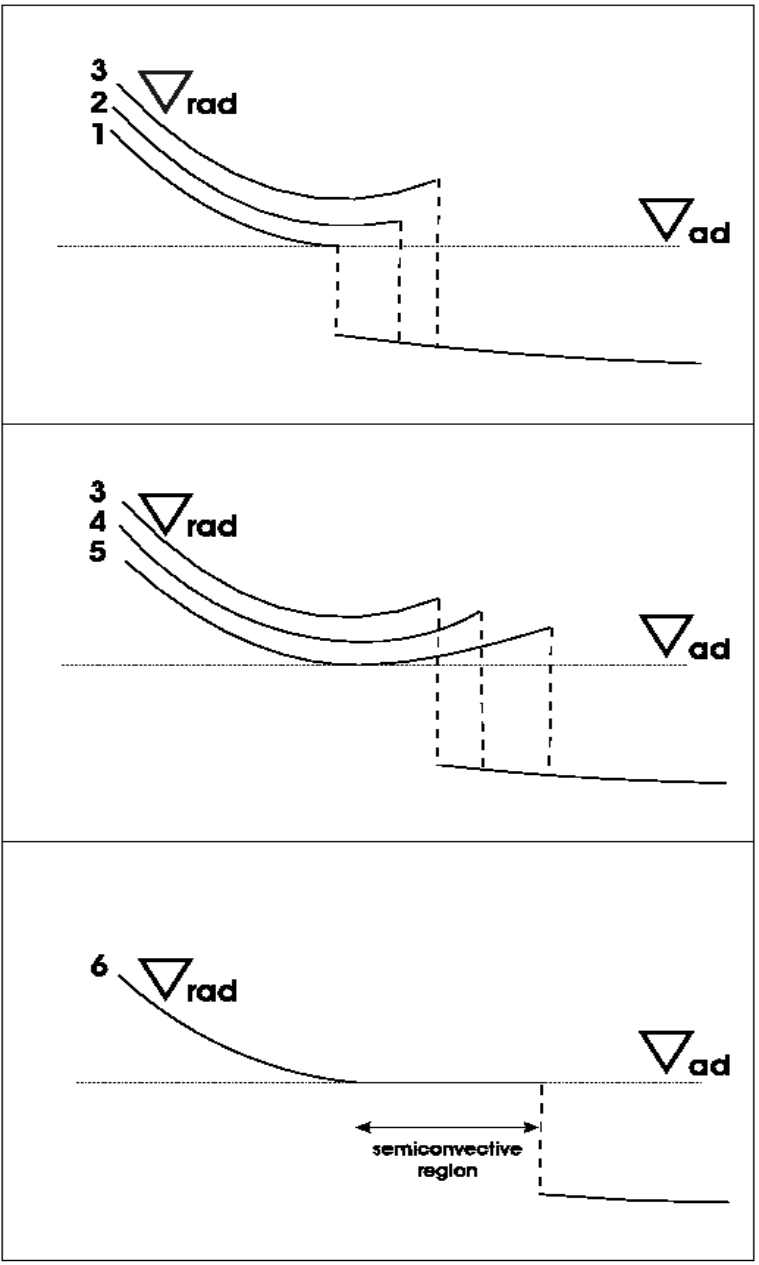


Mixing during core He-burning



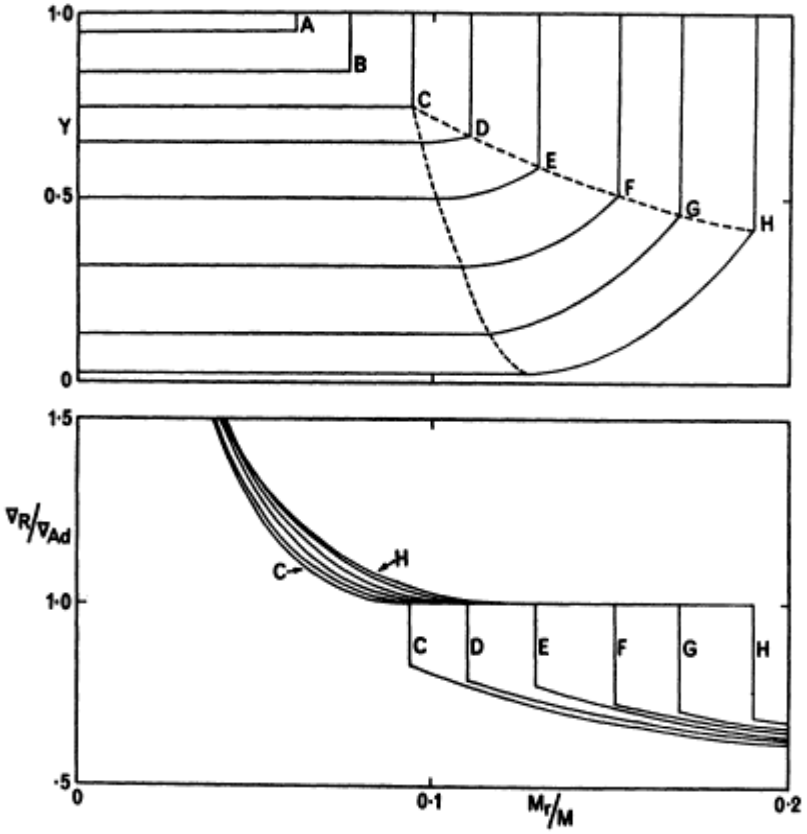


e.g. Schwarzschild and Harm (1969), Castellani et al. (1971), Gabriel et al. (2014), Constantino et al. (2015), Paxton et al. (2019)



When Y_c<0.7

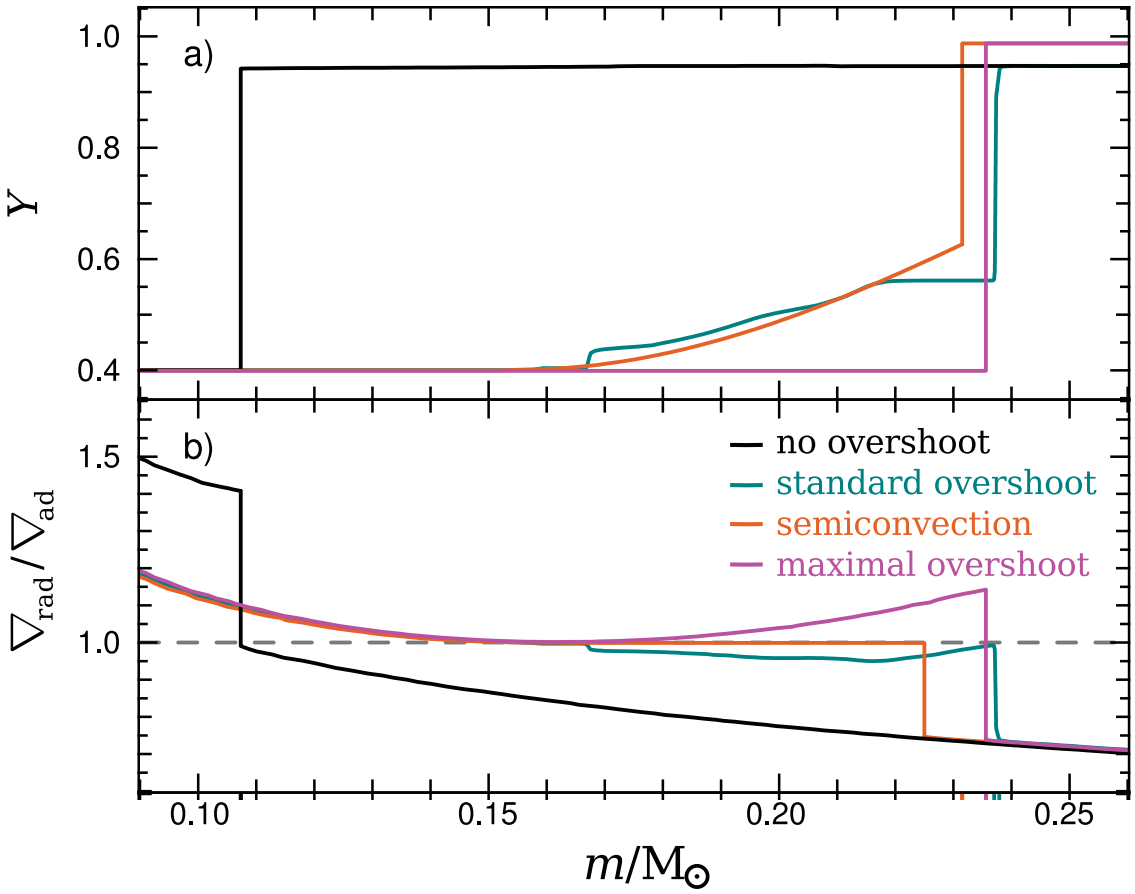
'semiconvection'



e.g. Castellani et al. (1985)

Y_c=0.4

1 $M_\odot$



Constantino et al. (2015)

CONSEQUENCES FOR WD CO ABUNDANCE PROFILES

Straniero et al. (2003)

	τ_{He}	X_C	X_O
BSM	88	0.42	0.56
SM	145	0.19	0.79
PSM	134	0.40	0.58
HOM	153	0.42	0.56
LOM	139	0.38	0.60

Central abundances

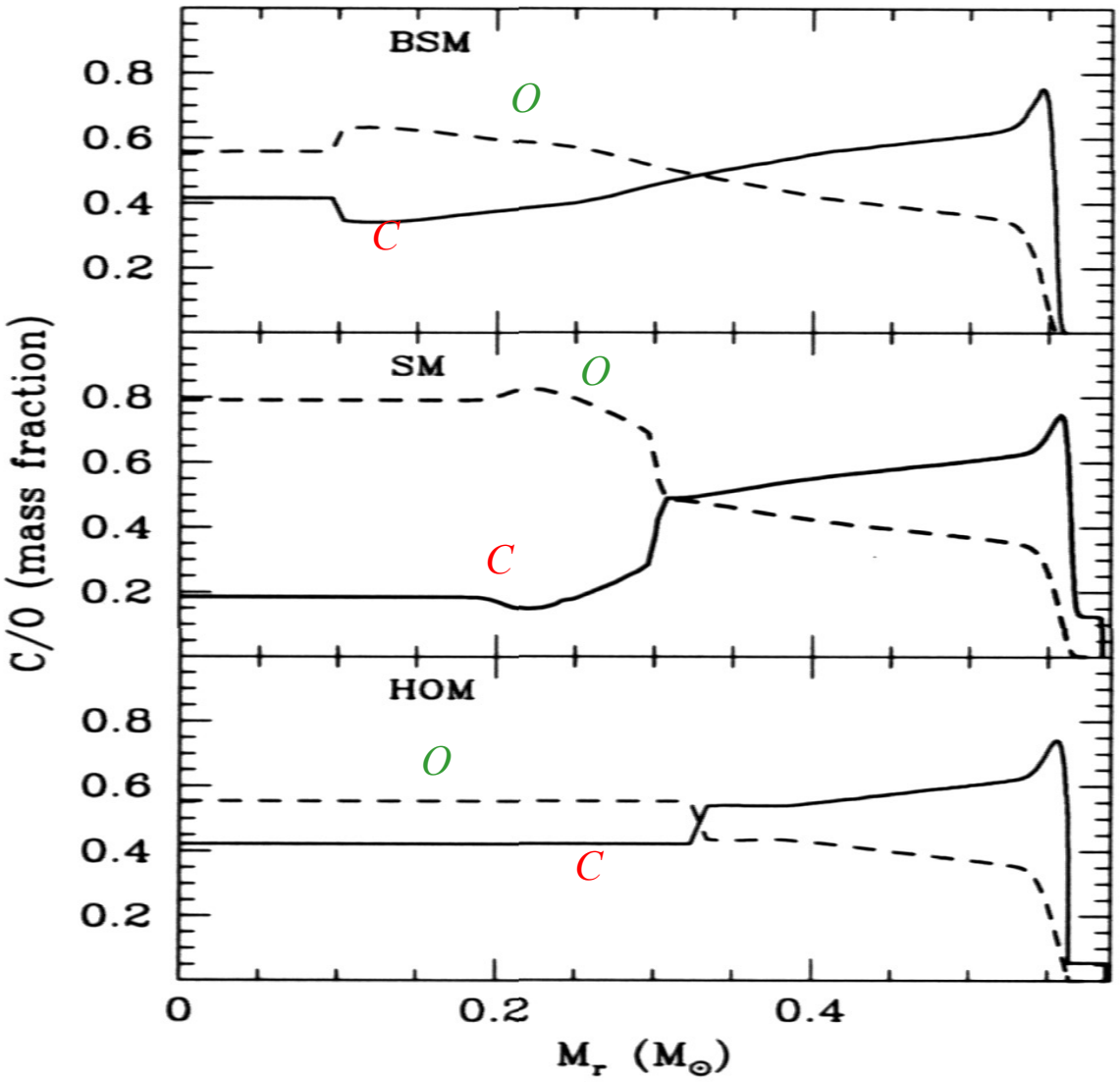
$3M_\odot$ solar composition

BSM =no oversh., no semiconv.

SM and PSM = semiconv. + 2 different methods to suppress BPs

HOM = overshooting 1Hp (BP suppressed as in SM)

LOM= overshooting 0.2Hp (BP suppressed as in SM)

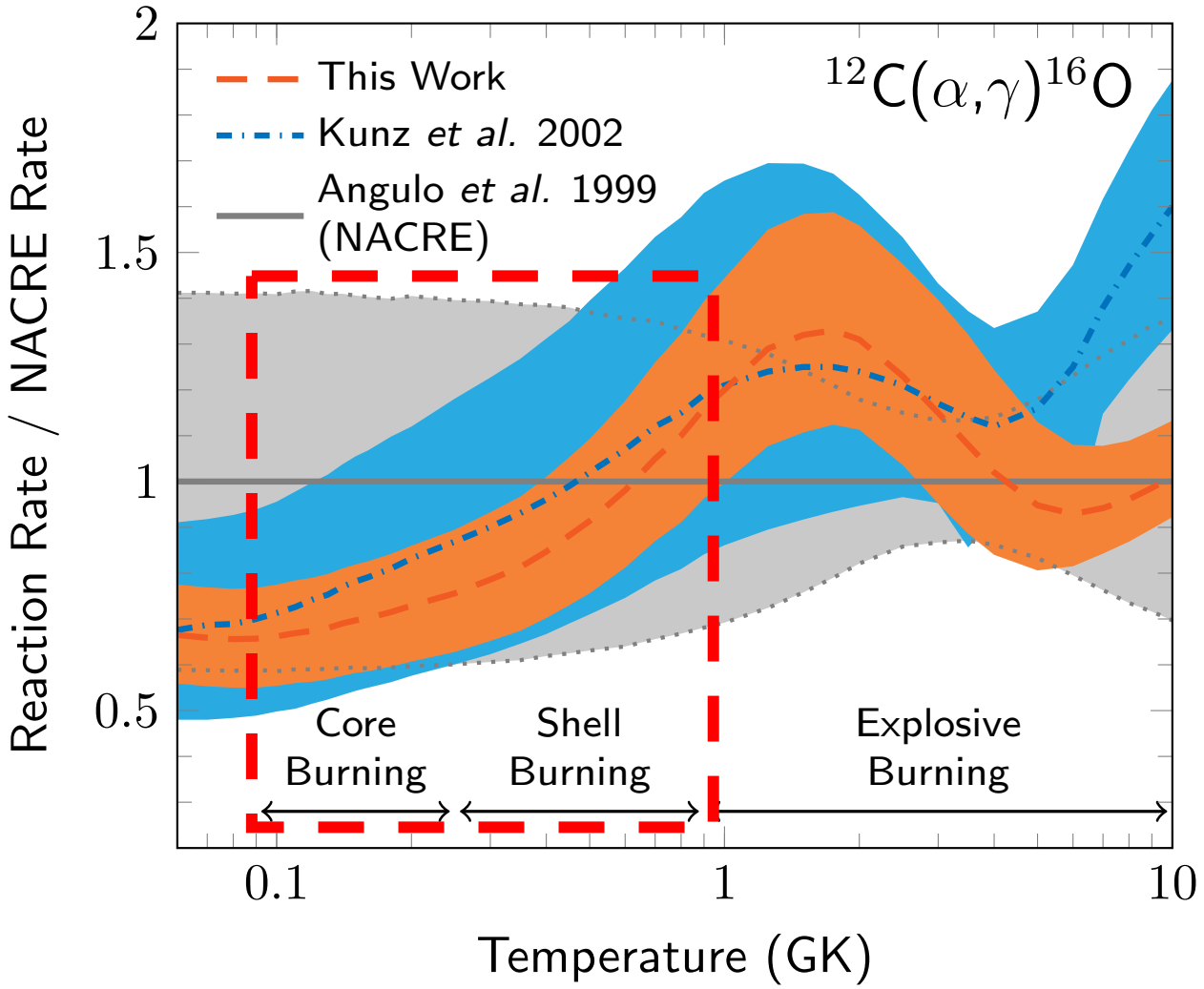


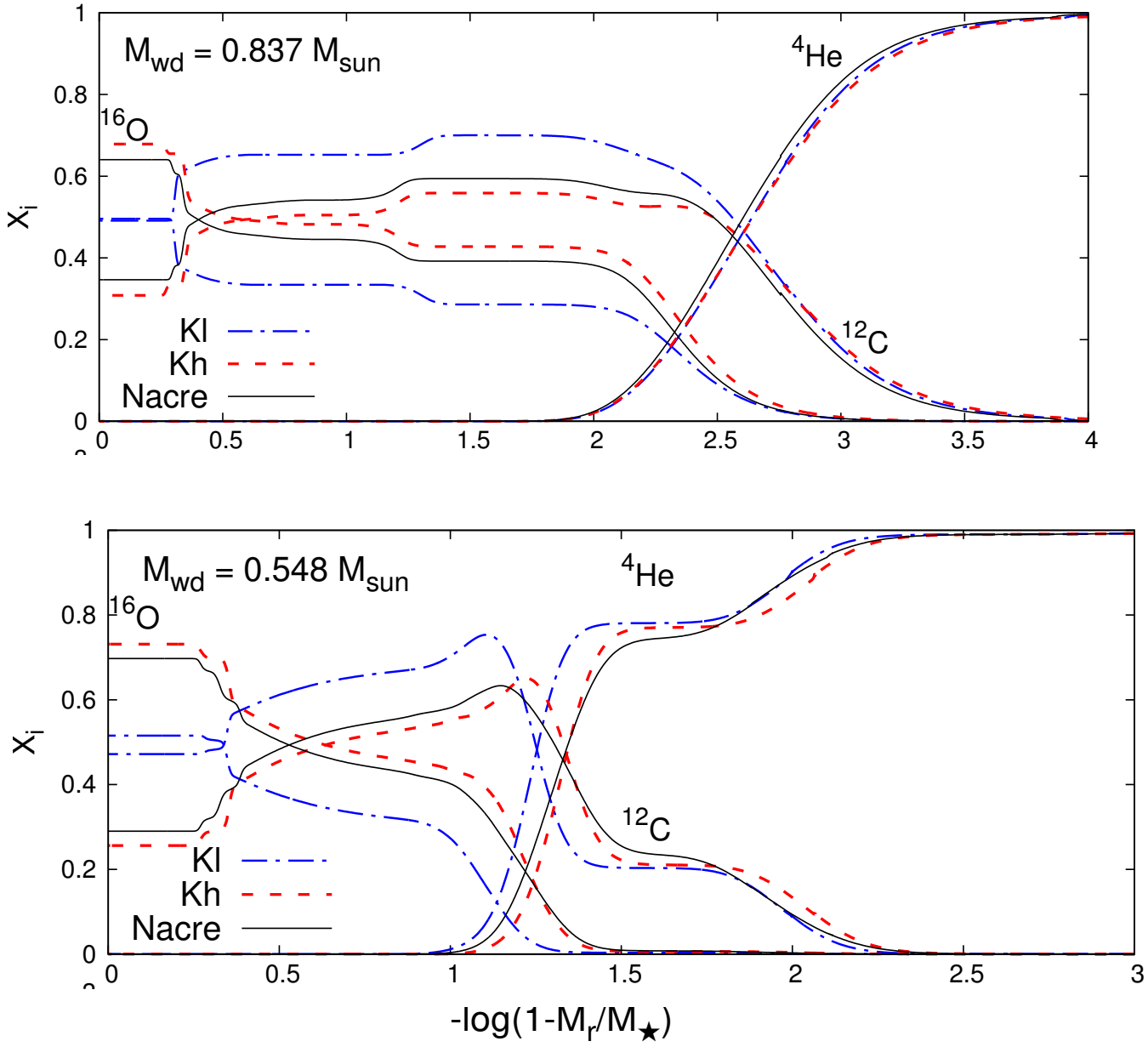
Straniero et al. (2003)

Chemical stratification at the onset of AGB thermal pulse phase

$^{12}C(\alpha,\gamma)^{16}O$ reaction rate

DeBoer et al. (2017)

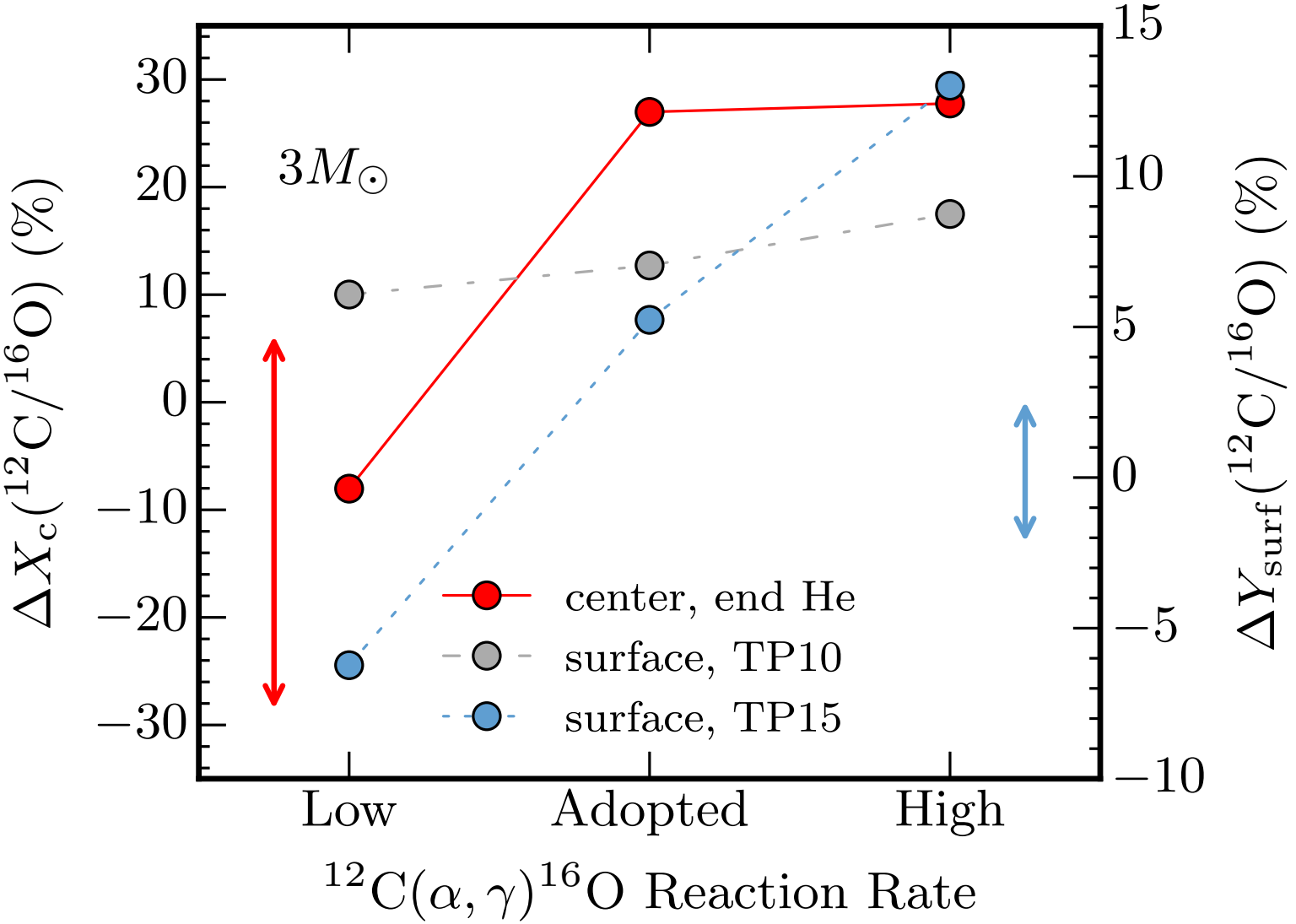




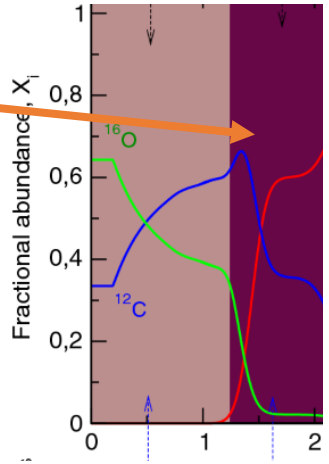
De Geronimo et al. (2017)

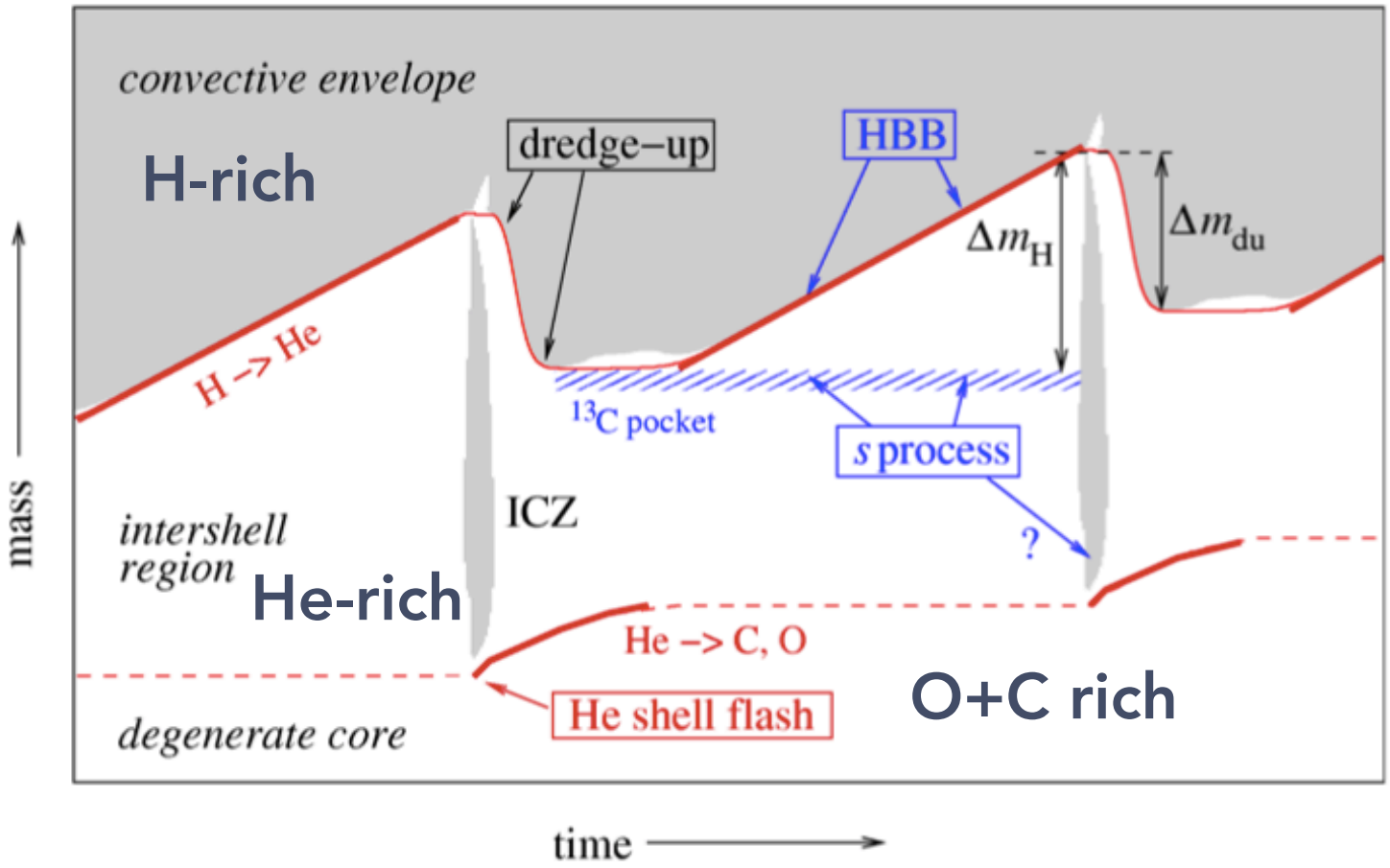
Percentage difference of C/O abundance ratios (DeBoer-Kunz rates)

DeBoer et al. (2017)

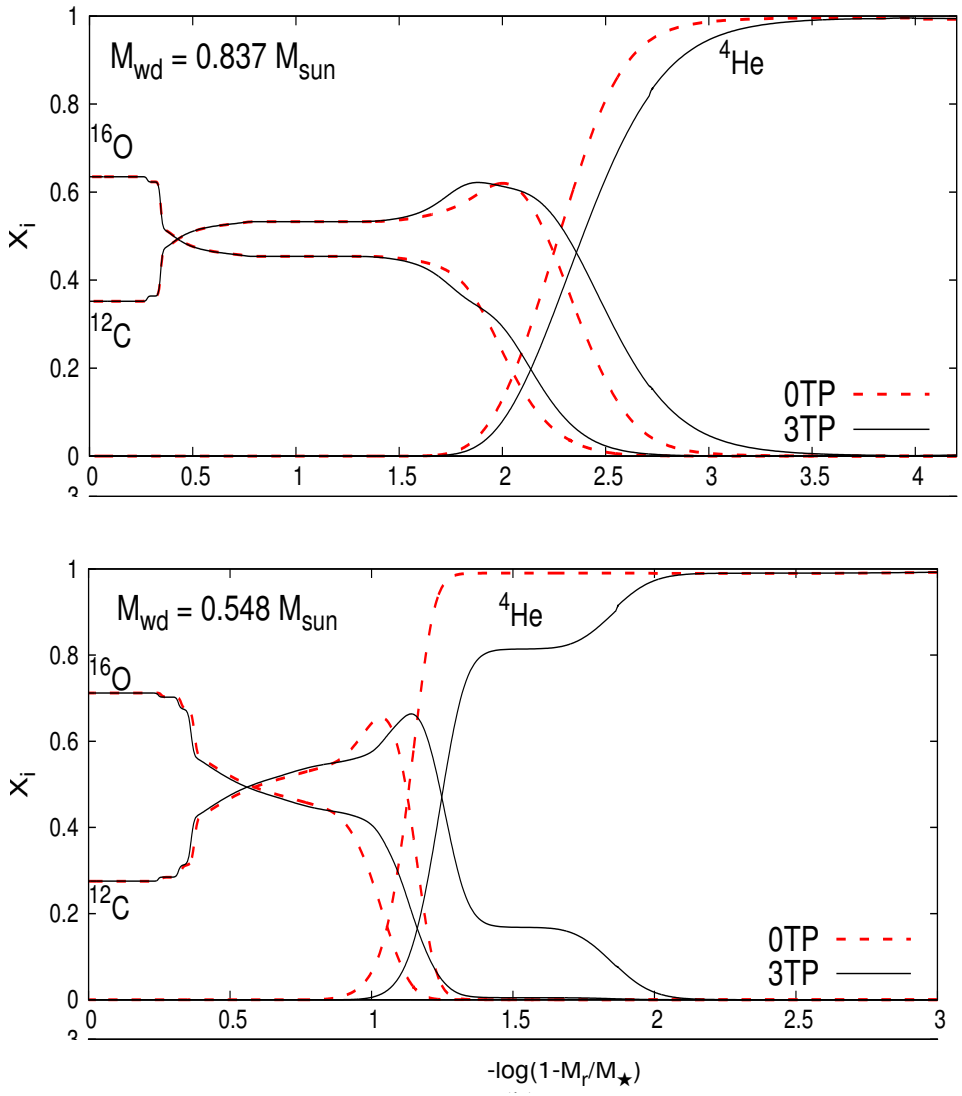


The thermal pulses



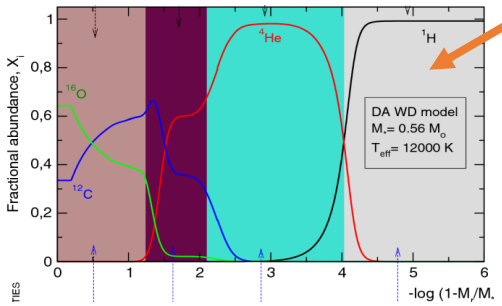


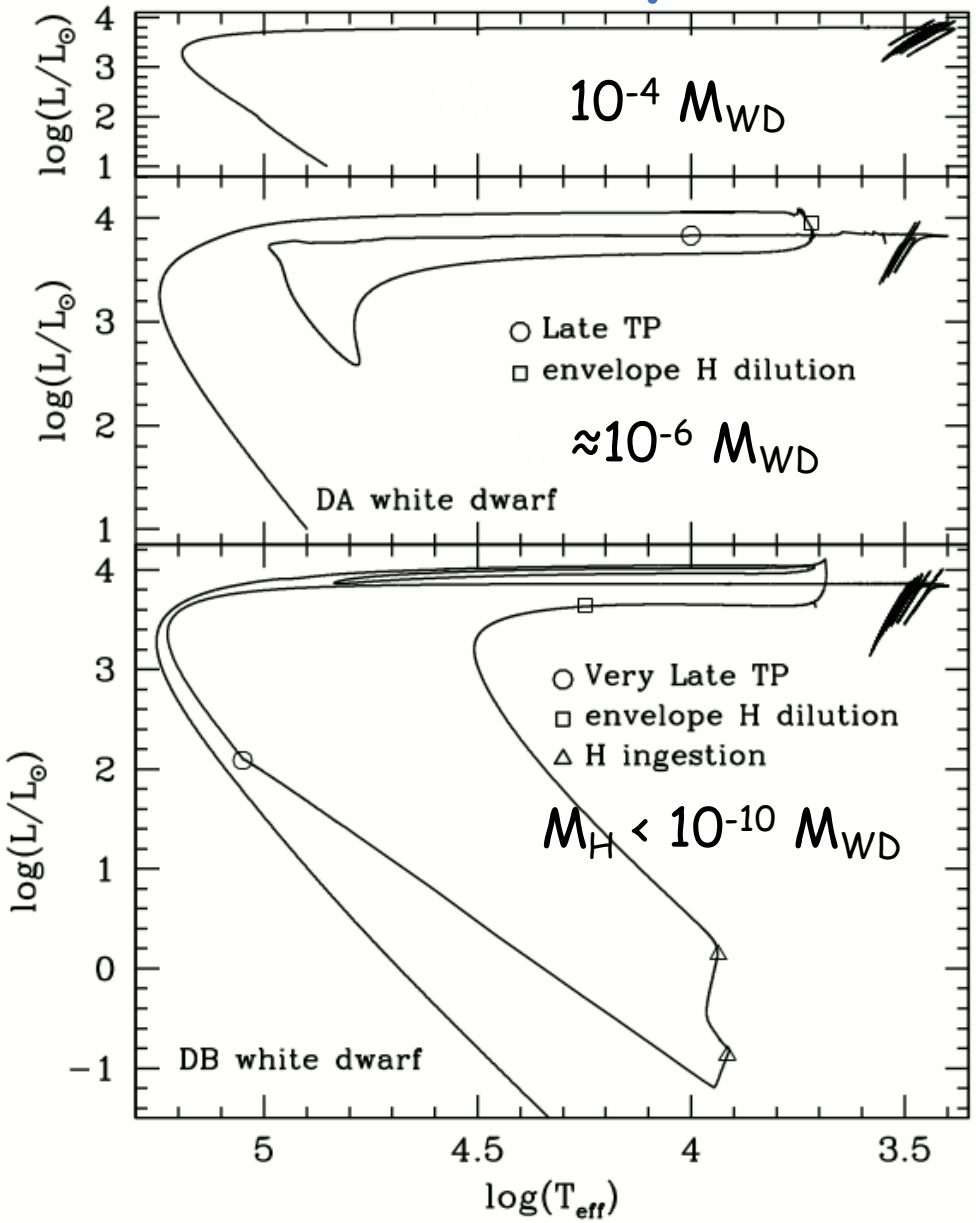
The thermal pulses



De Geronimo et al. (2017)

Late thermal pulses





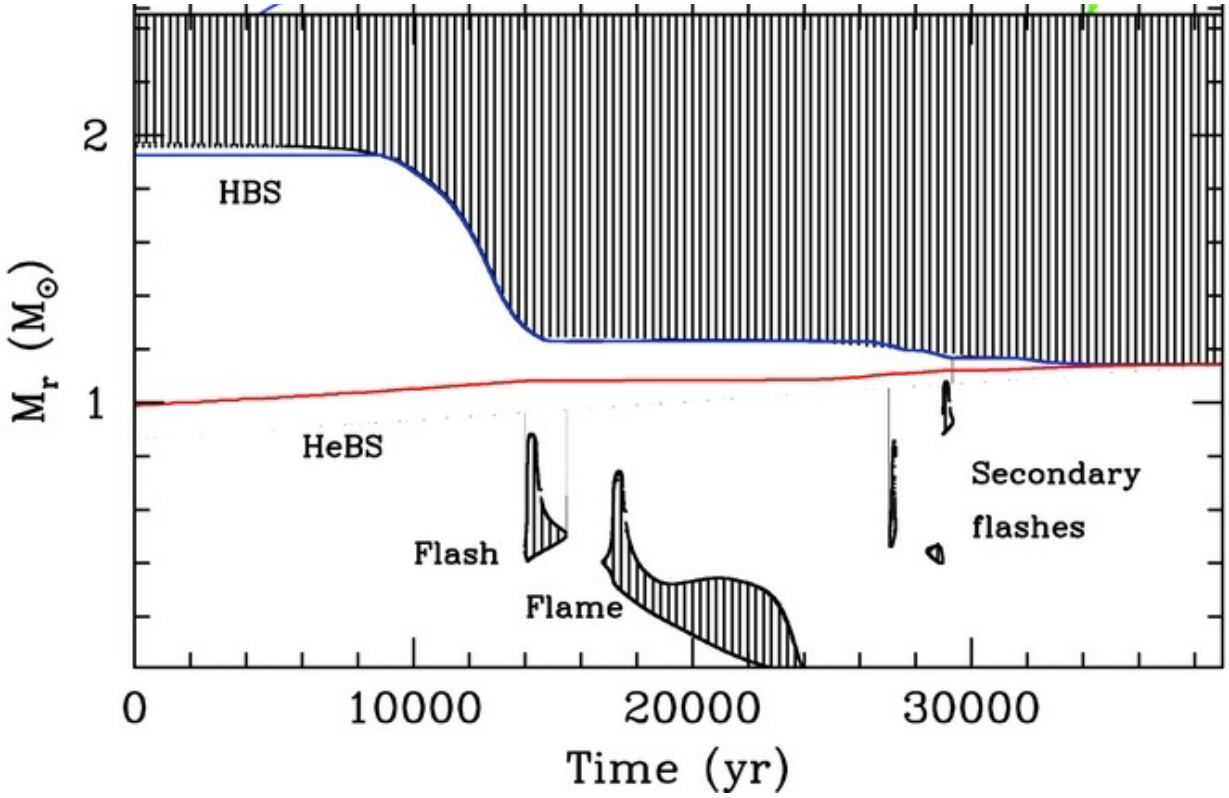
e.g. Herwig et al. (1999), Althaus et al. (2005), Miller Bertolami et al. (2017)

Super-AGB evolution and ONe WDs

Doherty et al. (2015)

$8.5M_{\odot}$

$$
\begin{aligned}
^{12}C + {}^{12}C &\rightarrow {}^{16}O + 2\,{}^{4}He \\
&\rightarrow {}^{20}Ne + {}^{4}He \\
&\rightarrow {}^{23}Na + p^{+} \\
&\rightarrow {}^{23}Mg + n \\
&\rightarrow {}^{24}Mg + \gamma
\end{aligned}
$$



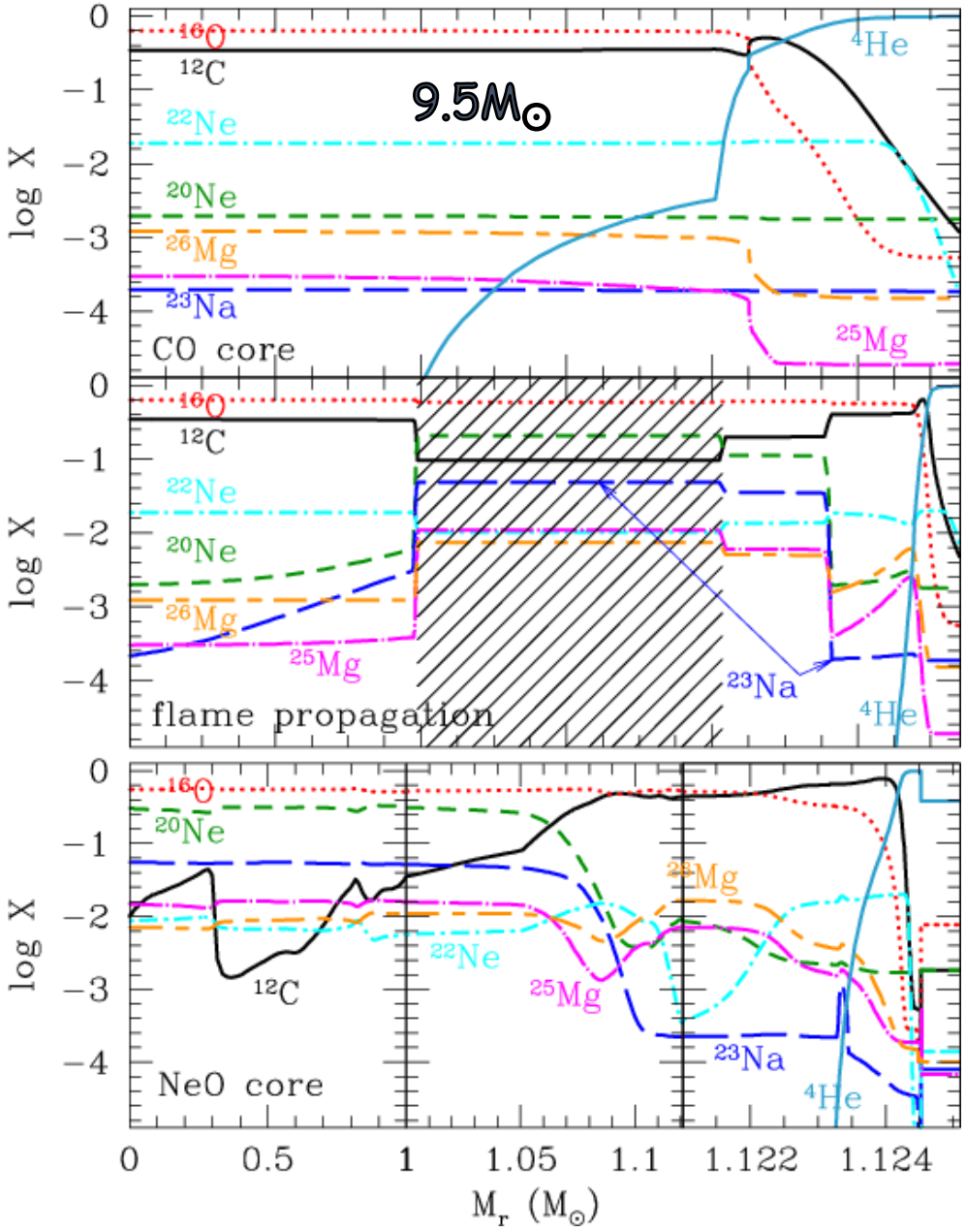
Off-centre carbon ignition in a weakly-degenerate core (T ~ 6.4 X 10^8 K)

e.g. Garcia-Berro et al. (1997), Siess (2006), Denissenkov et al. (2013) Chen et al. (2014), Doherty et al. (2015), Farmer et al. (2015),

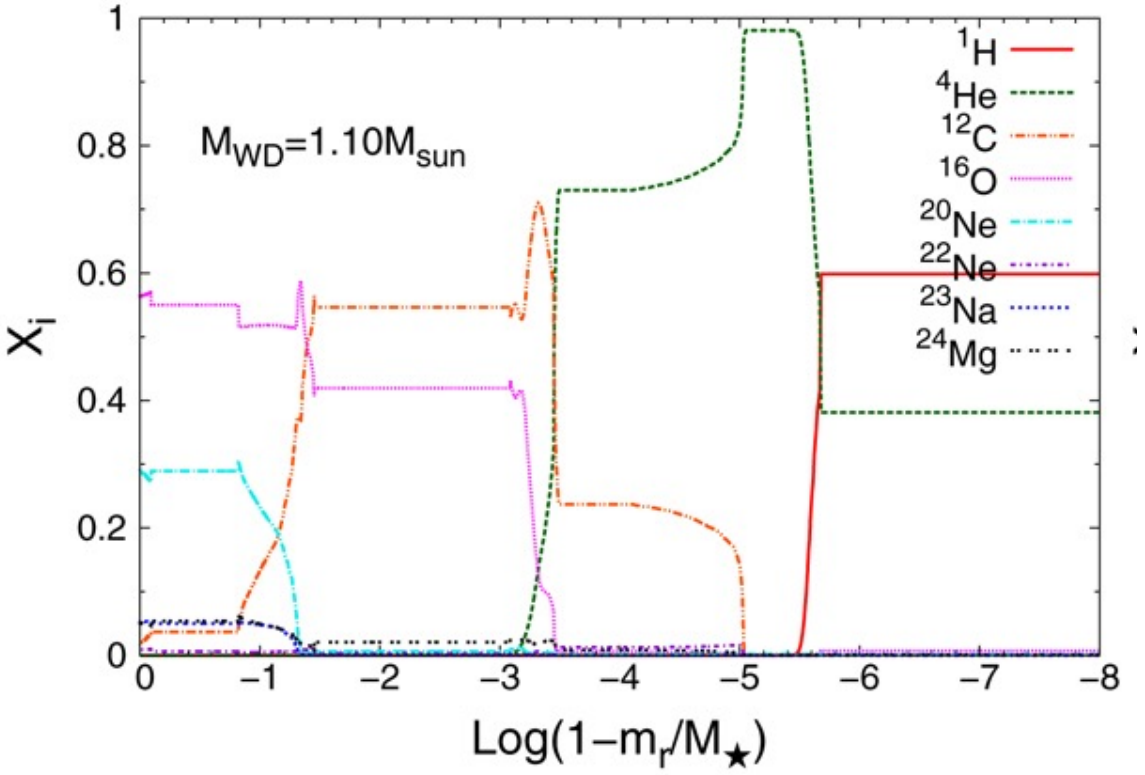
end core He-burning

Siess (2006)

beginning super-AGB phase

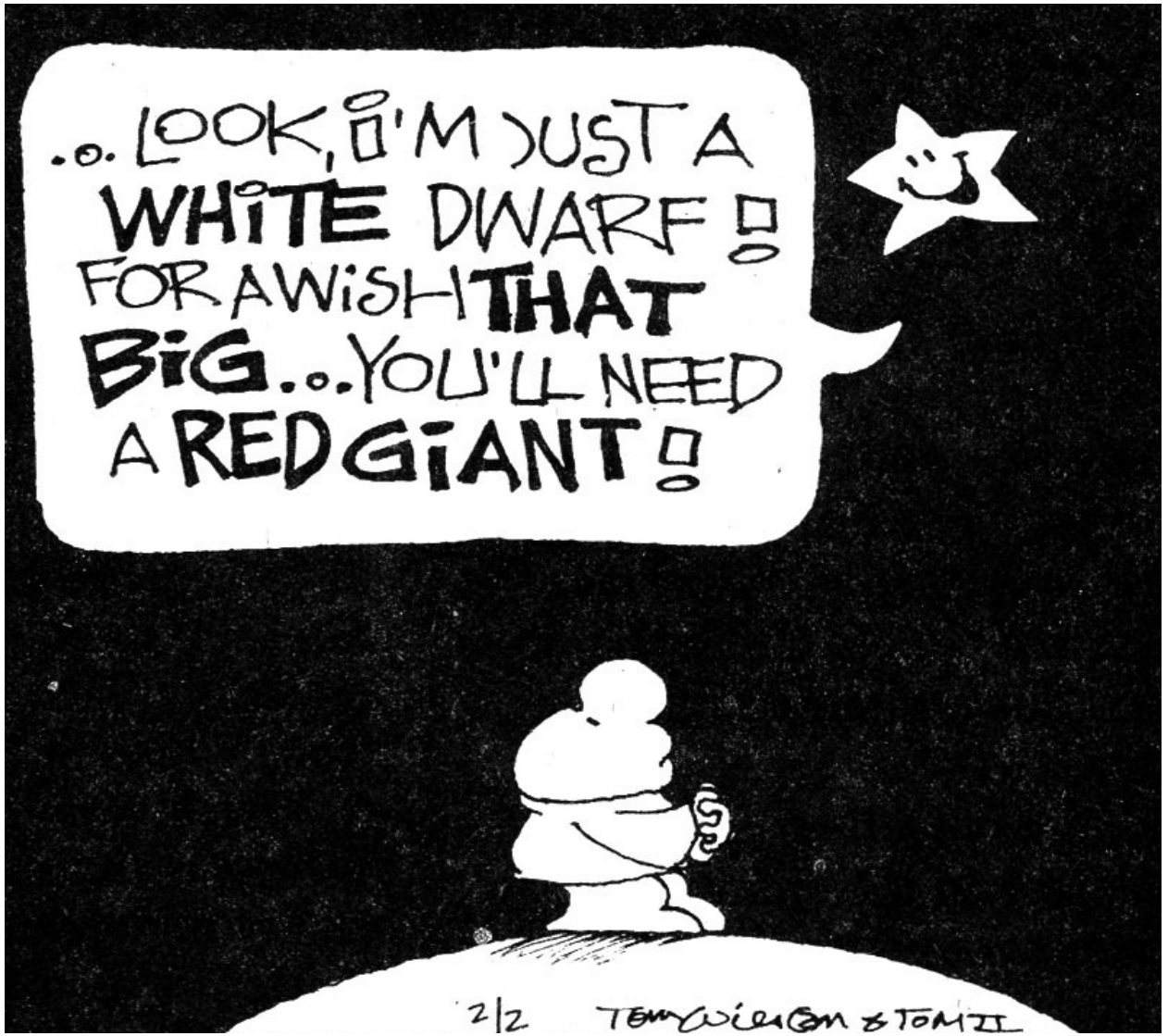


Chemical stratification ONe-core WDs



But it is possible that C-burning does not reach the centre (uncertainties in the reaction rates and mixing treatment) . In that case, the inner core composition would be roughly that of a CO-core WD

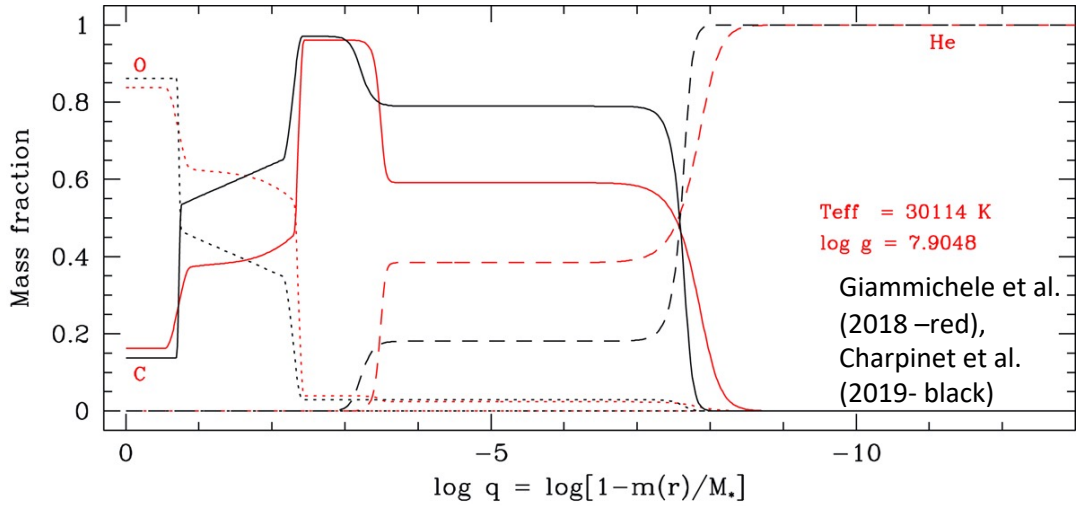
Camisassa et al. (2019), chemical profiles from Siess (2007, 2010)


..o. LOOK, I'M JUST A WHITE DWARF! FOR A WISH THAT BIG...YOU'LL NEED A RED GIANT!
2/2 TOM WILSON & TOM II

Food for thought

KIC 08626021

DB white dwarf



log*g* (cm s^{-2})	7.92 ± 0.01	7.905 ± 0.014
$T_{\rm eff}$ (K)	29, 968 ± 198	30 114 ± 210
$X(\rm O)_{\rm centre}$	0.86 ± 0.04	0.84 ± 0.04
$M(\rm He)/M_*$ (%)	0.0113 ± 0.006	0.0133 ± 0.0063
$M(\rm C)/M_*$ (%)	21.96 ± 4.2	20.76 ± 1.1
$M(\rm O)/M_*$ (%)	78.03 ± 4.2	79.23 ± 1.1
$M_*/M_\odot$	0.570 ± 0.005	0.562 ± 0.006
$R_*/R_\odot$	0.0138 ± 0.0001	0.0139 ± 0.0001

This stratification cannot be reproduced by stellar evolution models

(De Geronimo et al. 2019)