α-element enhanced opacity tables and low-mass metal-rich stellar models

A. Weiss, M. Salaris, J.W. Ferguson, D.R. Alexander

astro-ph/0605666

Two α-enhanced mixtures

element	recipe Francesca	log enh.	recipe Paula	log enh.
C	0.076535		0.083953	
N	0.023483		0.024600	
O	0.673656	0.50	0.573606	0.40
Ne	0.083031	0.29	0.128651	0.40
Na	0.000883		0.001038	
Mg	0.041697	0.40	0.049009	0.40
Al	0.001589		0.001868	
Si	0.035717	0.30	0.052850	0.40
P	0.000157		0.000184	
Si	0.019972	0.33	0.036357	0.40
Cl	0.000201		0.000237	
Ar	0.002375		0.002118	
K	0.000093		0.000109	
Ca	0.005215	0.50	0.004869	0.40
Ti	0.000384	0.63	0.000266	0.40
Cr	0.000437		0.000513	
Mn	0.000242		0.000285	
Fe	0.032459		0.037284	
Ni	0.001874		0.002203	
	mix α–v		mix α–c	

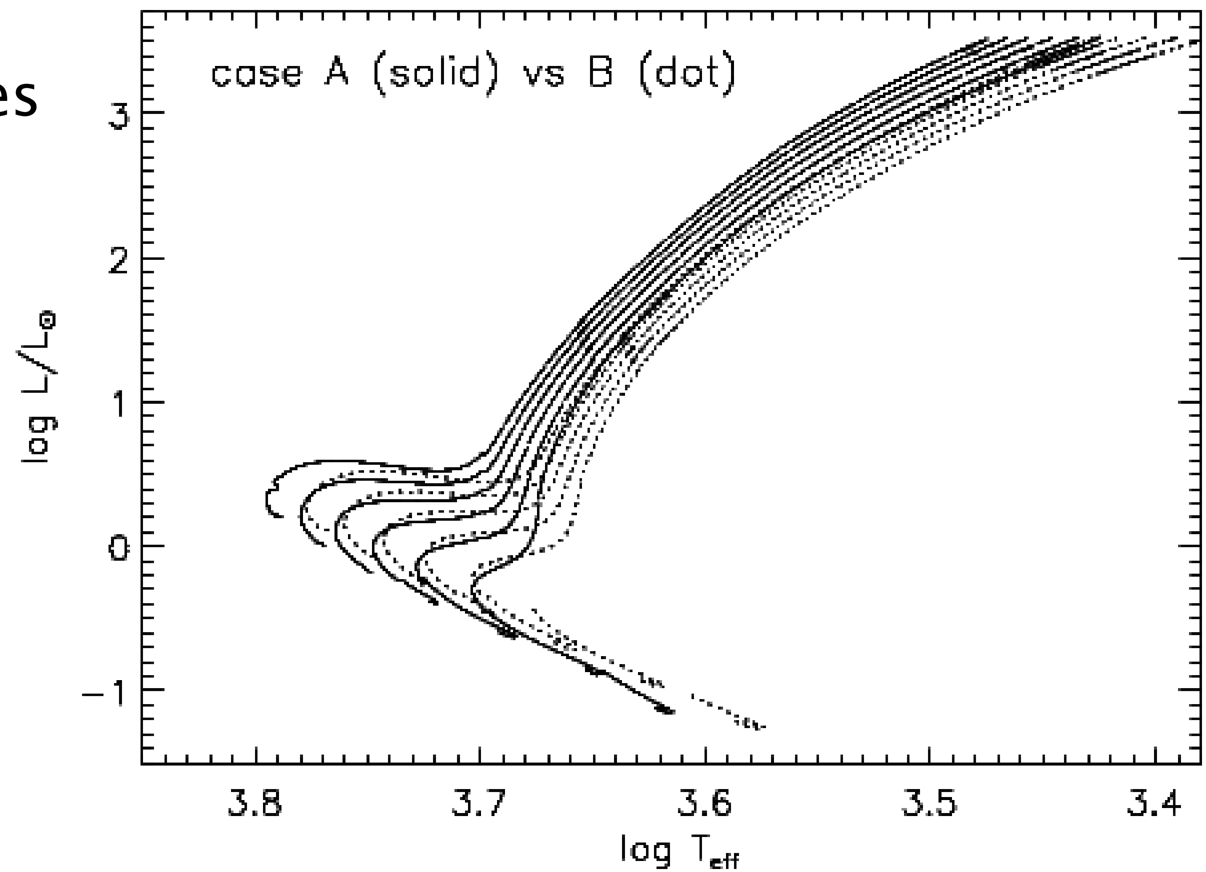
α–v used in: Weiss et al. (1995), Salaris & Weiss (1996–2002), Salasnich et al (2000)

models

- stellar models with metal distribution α−c
- X=0.679, Y=0.289, Z=0.032
- set A: Alexander & Ferguson (1994) and OPAL (1996) α−enhanced opacities for mixture α−v
- set B: Ferguson (2005) and OPAL (2005) α−enhanced opacities for α−c
- everything else identical
- mass range 0.6 – 1.3 $M_\odot$

surprise

- exchange of tables creates big difference
- much lower
  RGB temperatures
- lower MS luminosities
  (longer lifetimes)

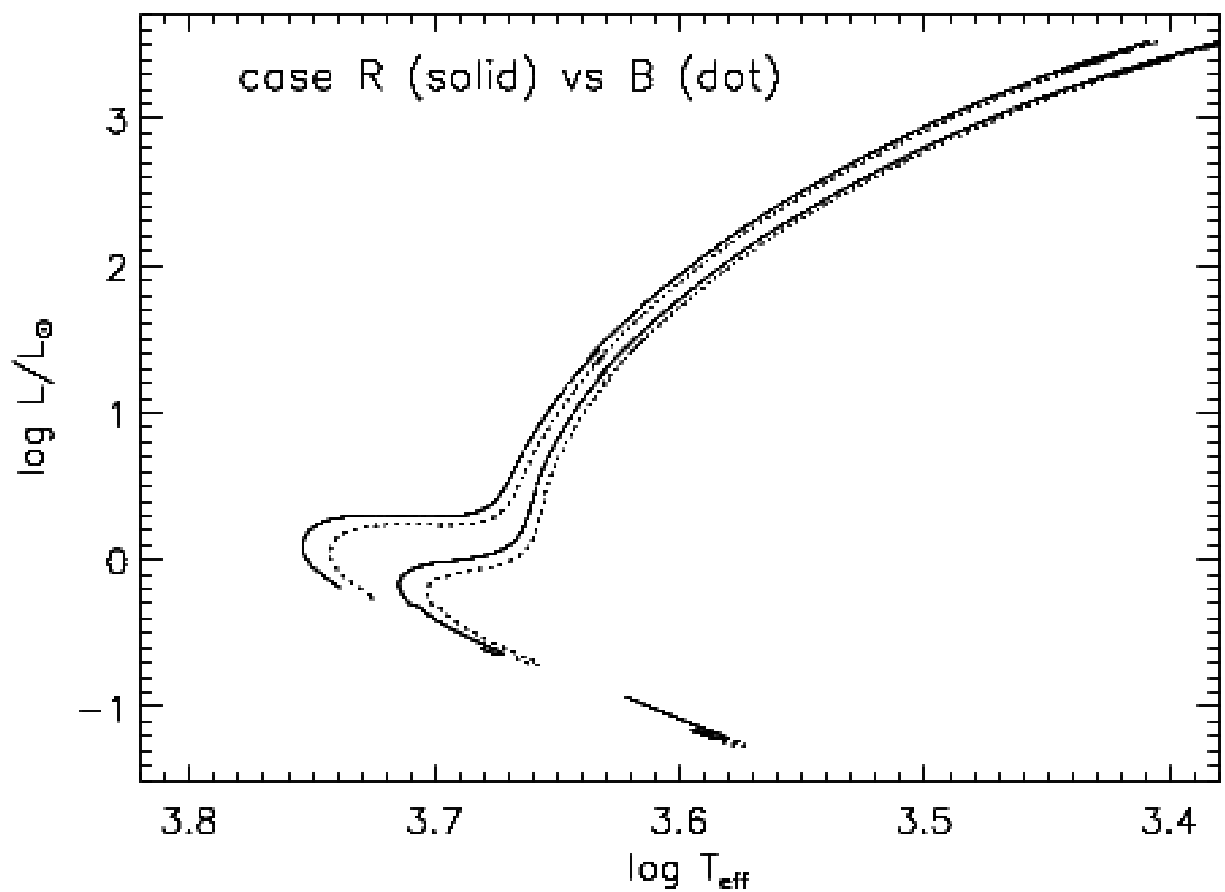


low–T opacities solution

- Alexander & Ferguson (1994) α–enhanced opacities tables were wrong [only THESE]
- error in procedure, not in code!
- replaced by new tables for identical mixture
  - with new Ferguson et al. (2005) code
  - with old AF94 code (without error)
  - small differences between these new table sets
  - big differences to original tables
- RGB effective temperature very close to those using the new tables for α–c mixture

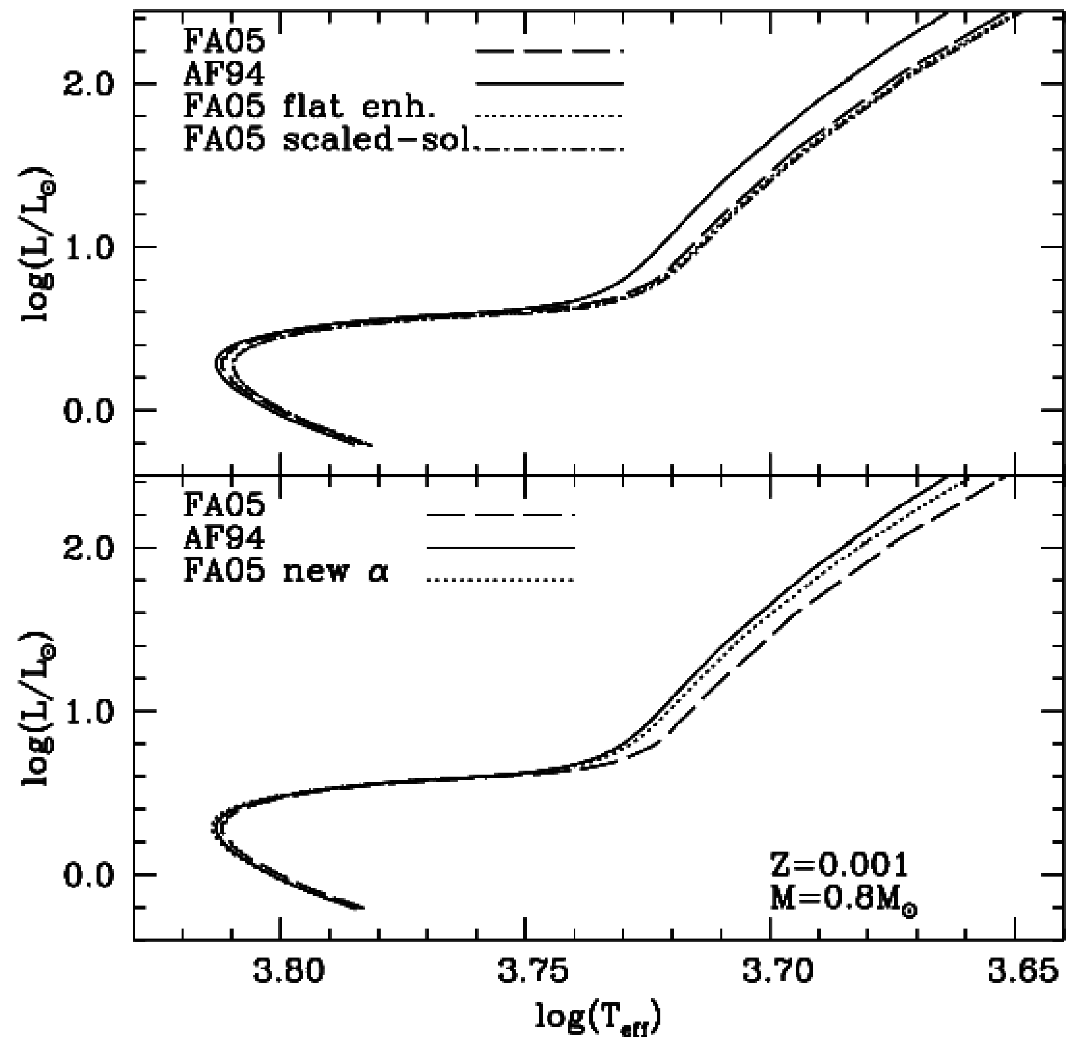
corrected low-T opacities

- for mixture α-v (case R)
- temperatures in much better agreement



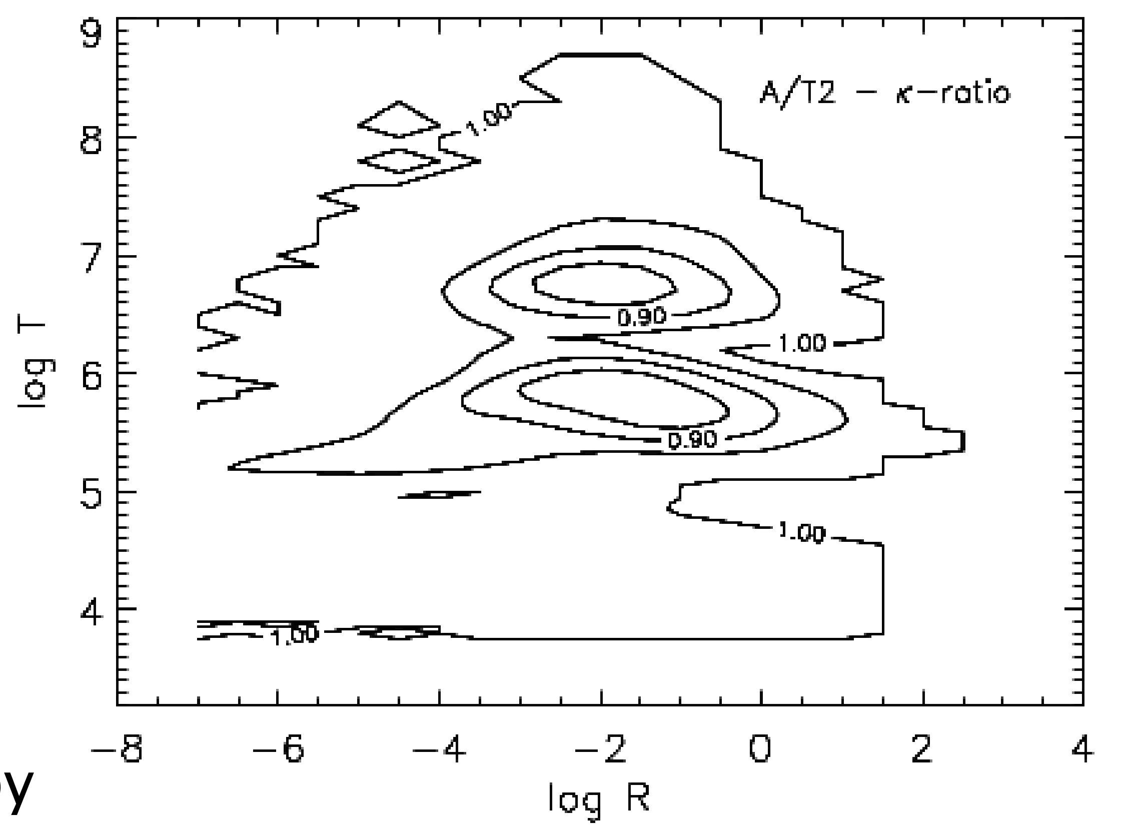
low metallicities – Z=0.001

- upper panel:
  with new tables no difference for different table mixtures
- lower panel:
  after solar model recalibration of α_{MLT} almost identical to old Salaris & Weiss (1998) track



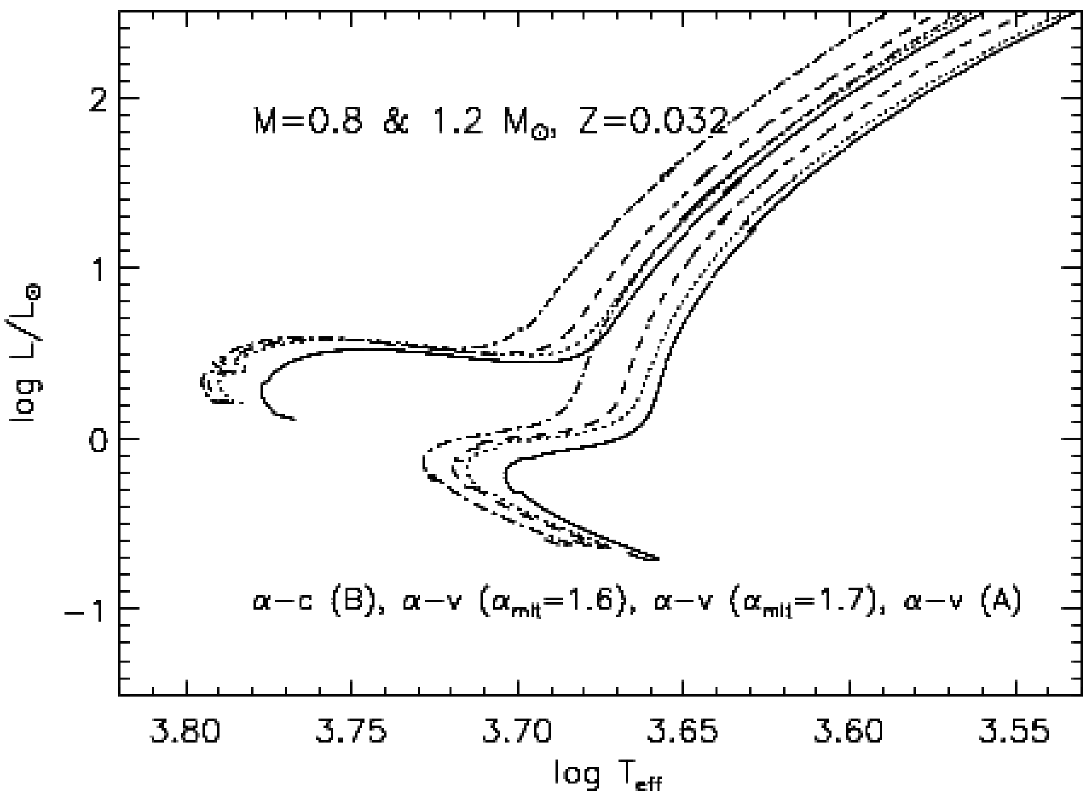
high-T temperatures

- real difference in OPAL-tables due to mixture differences
- systematically higher values for α-c mixture over large T-ρ-range
- several tests exclude error in production of tables
- additional test using Opacity Project confirms effect
- it is real
- MS lifetimes increased by 10-20%



high-metallicity summary

- solid line:
  α-c in models and tables
  low RGB-T_e, low MS-L
- dotted:
  α-v in models and tables
  similar RGB-T_e, higher MS-L
- dashed:
  α-v with recalibrated α_{MLT}
- dash-dotted:
  old α-v; erroneous tables,
  not recovered



the bottom line

- Alexander & Ferguson tables of 1994 for α–v mixture were wrong and have been replaced on Wichita molecular opacities website
- no consequence for low–Z cases (globular cluster work by Salaris & Weiss)
- strong influence at solar metallicity (and above); tracks should be recalculated (Salasnich et al 2000)
- element ratio differences (at fixed Z) between α–v and α–c mixture strongly influence MS evolution of solar (and higher) metallicity models due to high–T opacities
- this refers to stellar tracks; for isochrones not yet investigated