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

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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)

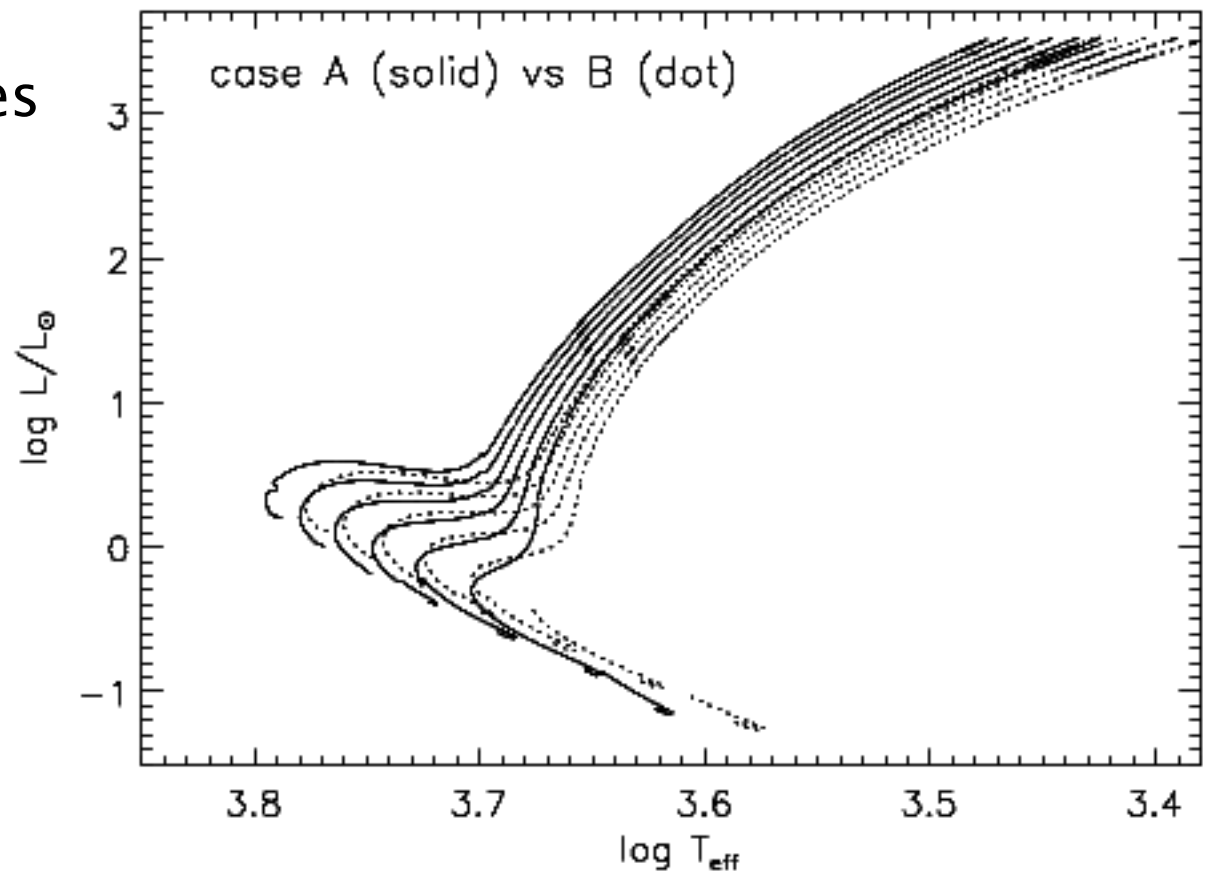
models

- 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)



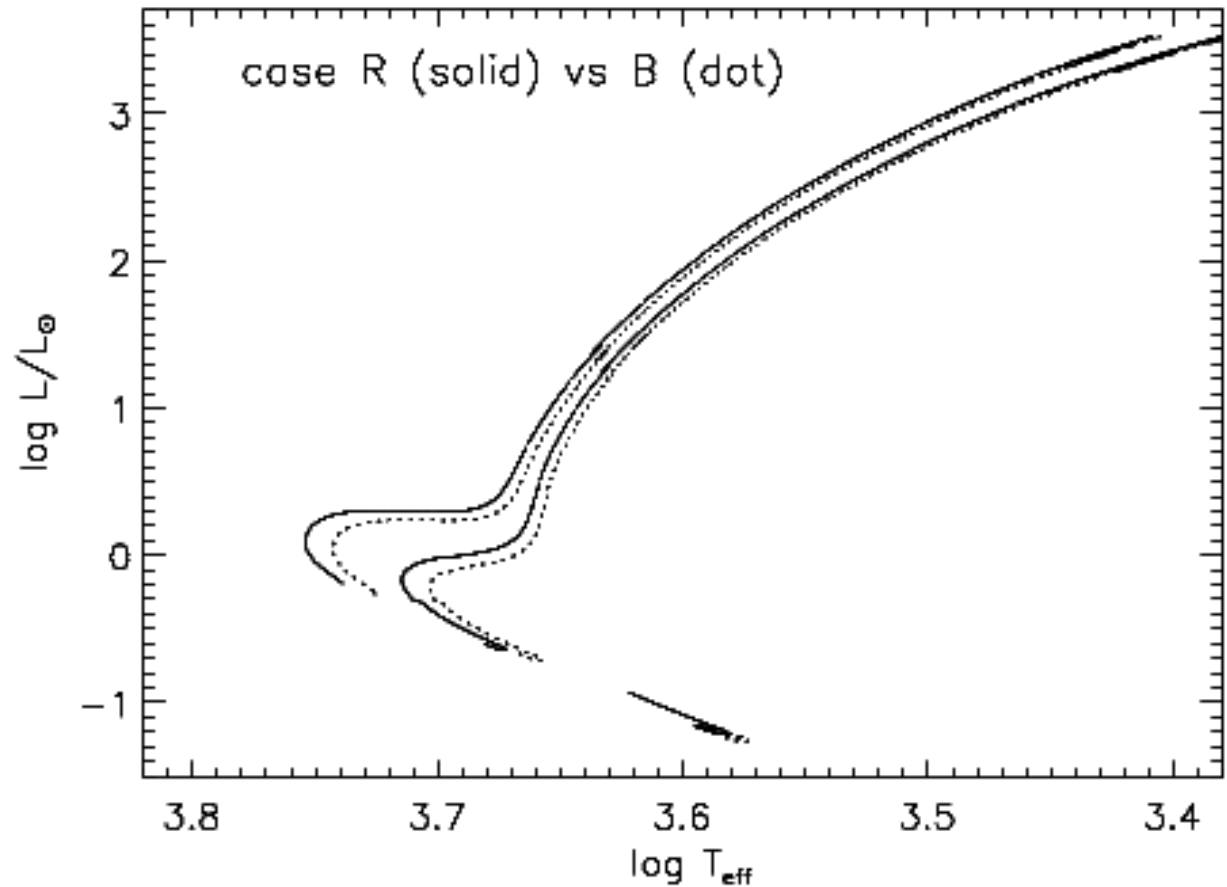
low-T opacities solution

- 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



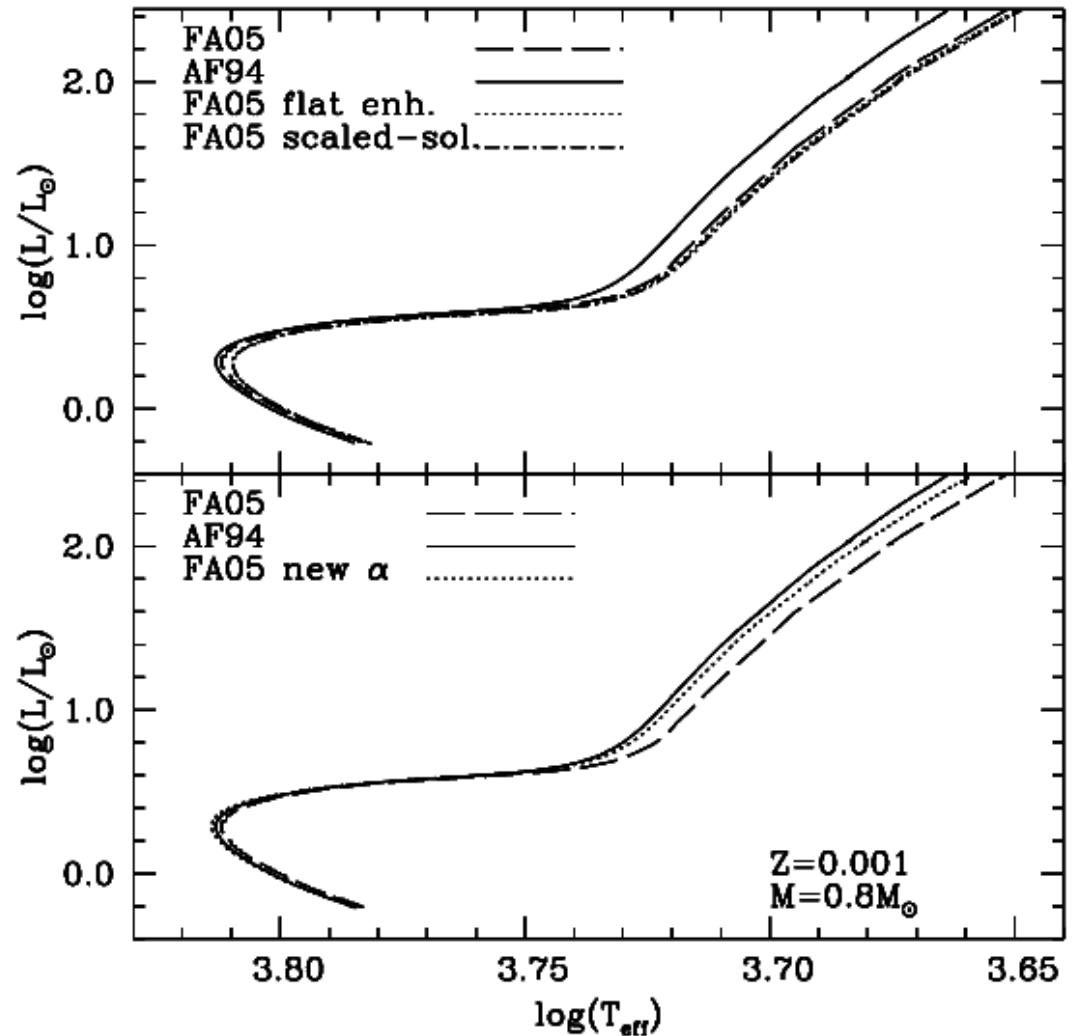
corrected low-T opacities

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



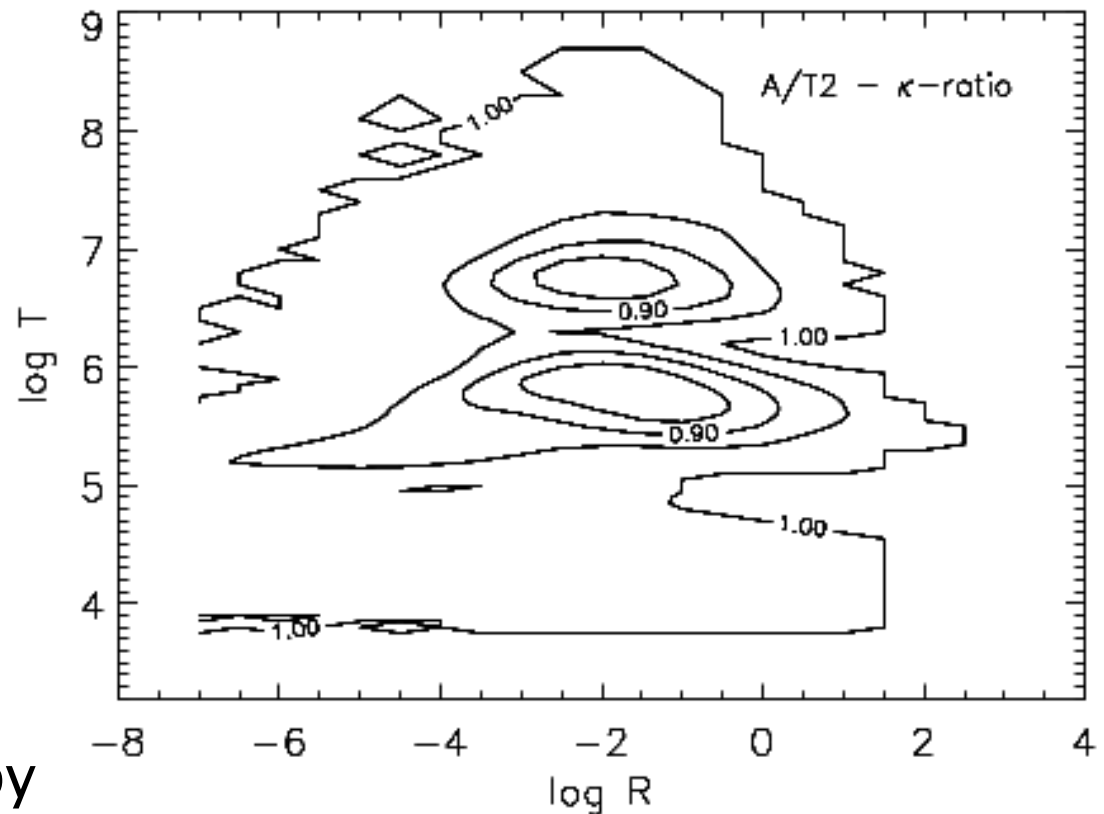
low metallicities - $Z=0.001$

- 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



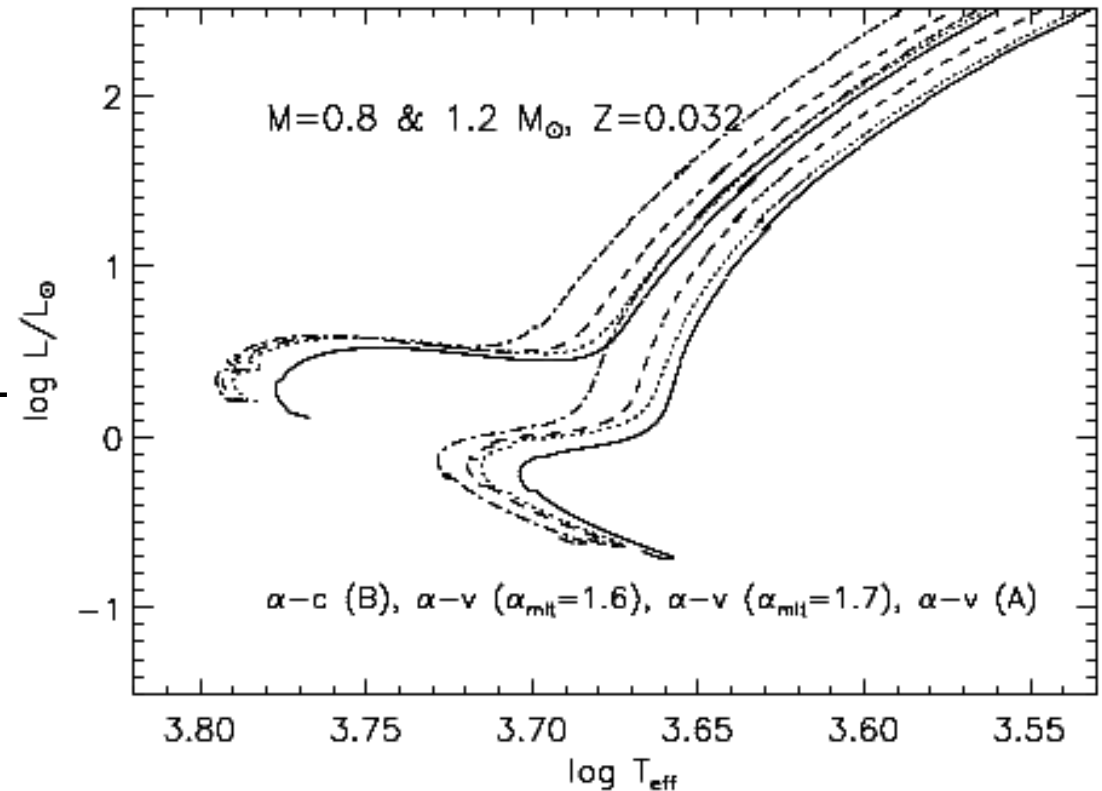
high-T temperatures

- 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

