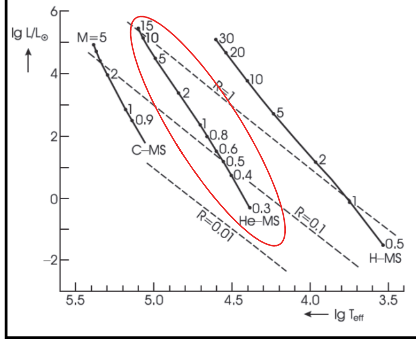
Other Main Sequences: the helium main sequence (He-MS)

Surface values (H-R diagram)

- Homogeneous models consisting almost (Z=0.021) completely of He.
- central He burning.
- He-MS is located far to the left of H-MS.
- for M = const. L is much larger and R is smaller than for H-MS.



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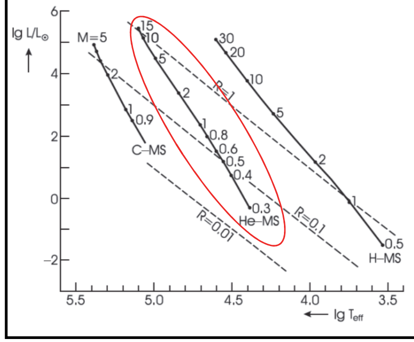
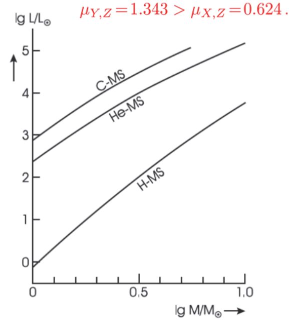
because of $\mu_{Y,Z} = 1.343 > \mu_{X,Z} = 0.624$.

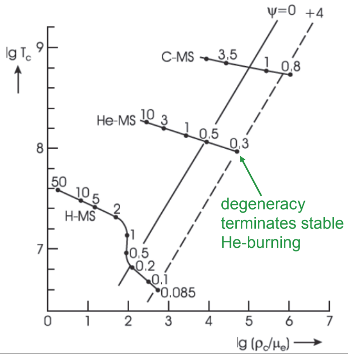




Other Main Sequences: the helium main sequence (He-MS)

Interior solutions: T_c, ρ_c

- Interior solutions similar to models on the upper H-MS.
- larger T-dependence of He burning leads to concentrated energy-generating and convective core.



- also P_{rad} contributes to growing convective core:
  - 1.5% of P_{tot} @ centre of 1 $M_\odot$
  - 18% of P_{tot} @ centre of 5 $M_\odot$
  - 32% of P_{tot} @ centre of 10 $M_\odot$

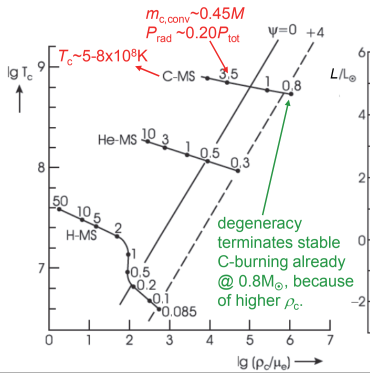
  \>> H-MS,

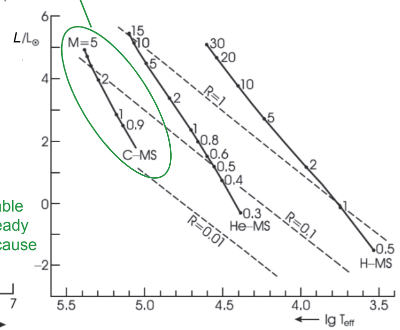
  because $T_{He} \sim 6 \times T_H$.
- He-MS stars have much larger ρ_c: $\rho_c \sim 10^5 \mathrm{gcm}^{-3}$ for 0.3 $M_\odot$ with same ψ as lower end of H-MS, despite higher T.

Note: abscissa is ρ_c/μ_e to allow plotting common ψ (μ_e=2 for He- and C-MS; μ_e=1.19 for H-MS).

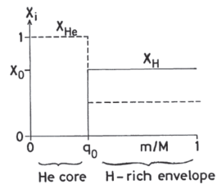
Other Main Sequences: the helium main sequence (C-MS)

- Additional to Z, homogeneous composition is either ^{12}C or mixture of ^{12}C & ^{16}O.
- these homogeneous C-MS models describe C-burning cores of highly evolved stars.
- For M=constant L is much larger and R smaller than for He-MS.



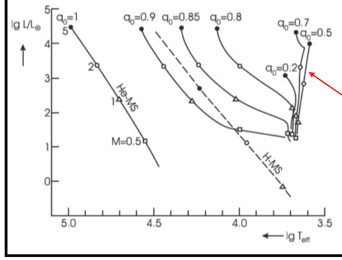


Other Main Sequences: generalized MS (GMS)



- Consider model in complete equilibrium with chemical profile shown in figure: He-core has mass fraction $q_0 = m_0/M$; H-envelope has mass fraction 1-q_0.
- Limits: q_0=0 … homogeneous H-MS
  q_0=1 … homogeneous He-MS.

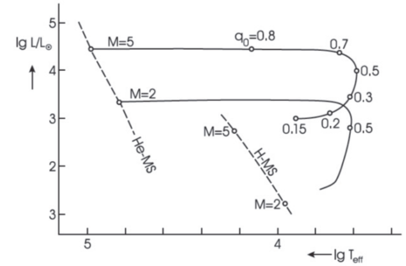
Models characterized by M and q_0



- q_0 <1 GMS is shifted quickly to the right and with $q_0 \approx$ 0.9…0.85 GMS has already crossed H-MS.
- behaviour changes dramatically for $q_0 \approx$ 0.8 …0.7, depending on M :GMS are then compressed together with closest approach for $q_0 \approx$ 0.5 – this is the so-called Hayashi line.
- for even smaller q_0 values GMS is shifted back again to the left.
- upper part of diagram can be covered by GMS models described by (M, q_0) only.

Other Main Sequences: generalized MS (GMS)

- Connecting models with same M on different GMS leads to (shown for 2 different M values):



- luminosity remains (nearly) constant for q_0 = 1,…,0.7 :
  caused by 2 opposite effects, nearly cancelling each other:
  (1) decrease of q_0 @ M=const. decreases M_{He} and therefore also L_{He} (according to M-L relation),
  (2) envelope mass (1- q_0)M increases, which increases L_H of H-shell source at same rate, such that L=L_{He} + $L_H \approx$ constant.
- For q_0< 0.7 sharp L_{He} decrease no longer compensated by L_H increase; L_H dominates L.
- Such simple models useful for e.g., study of binary star evolution (mass transfer changes q_0).