Very massive stars on the main sequence

- stars near the Eddington limit -

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Motivation

Aim:

I present a dense grid in initial masses and rotation rates of very massive stellar evolution models.

- study effects of mass loss and rotation on the main sequence evolution
- enrichment of elements at the surface
- chemical homogenous evolution
- calculate stellar evolution models of very massive rotating stars
- initial masses up to $500\,\mathrm{M}_\odot$ for LMC metallicity
- models taylored for the VLT FLAMES Tarantula Survey
- special: grid (with $M \leq 500\,\mathrm{M}_\odot$, LMC metallicity) with dense spacing in rotation rates
- basis for high resolution population synthesis

Grid of stellar evolution models

A one-dimensional stellar evolution code (Heger et al. 2000) with improvements from Petrovic et al. (2005) and Yoon et al. (2006) is used.

- convection: $\alpha_{\rm MLT} = 1.5$ (Böhm-Vitense 1985; Langer 1991)
- semiconvection: $\alpha_{\rm SEM} = 1$ (Langer et al. 1983; Langer 1991)
- convective core overshooting: $\alpha_{\rm over} = 0.335$ (Brott et al. 2011)
- rotational mixing: $f_{\rm c} = 0.0228$ (Heger et al. 2000; Brott et al. 2011)
- transport of angular momentum by magnetic fields: (Spruit 2002,2006)
- mass loss recipes: (Vink et al. 2000,2001; Nieuwenhuijzen & de Jager 1990; Hamann et al. 1995)
- LMC: X=0.7391, Y=0.2562, Z=0.0047 (not solar scaled)

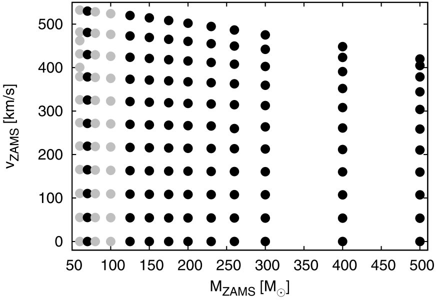


Figure: Grid of all initial masses and initial surface rotational velocities: grey dots are calculated by I. Brott.

The Hertzsprung-Russell diagram

- rotational mixing effect evolutionary tracks
- bending of the ZAMS visible
- models evolve near the Eddington limit
- strong decrease in luminosity occurs when Hamann et al. (1995) mass loss rate applied

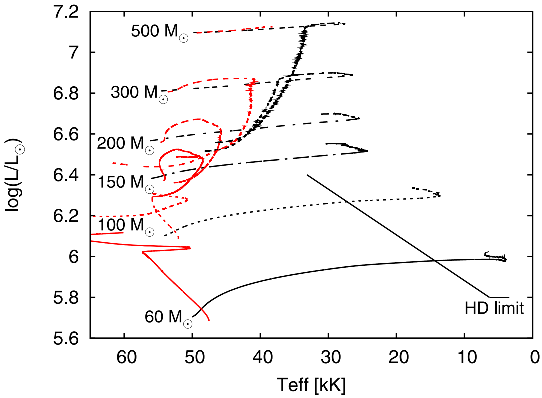
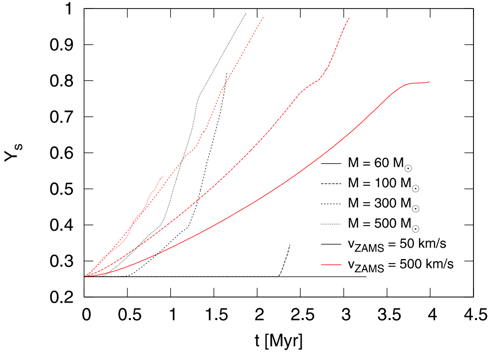


Figure: Hertzsprung-Russell diagram: non-rotating and fast rotating models ($v_{\mathrm{ZAMS}} = 500\,\mathrm{km/s}$) and the Humphreys-Davidson limit from Humphreys & Davidson (1994).

Helium mass fraction

Mass fractions and abundances of elements at the surface are indicators for rotational mixing.



- enhancement significantly affected by mass loss and rotating
- rotational mixing leads to increase at the surface
- mass loss exposes deeper layers leading to increase in mass fraction

Chemical homogeneous evolution

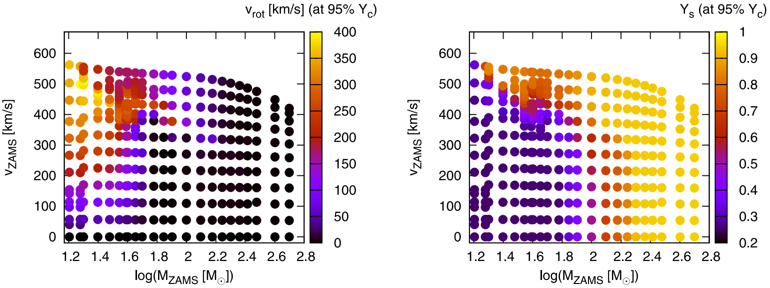


Figure: Stellar evolution models: surface rotational velocity in km/s (left) and helium mass fraction (right) at 95% of helium (mass fraction) in the core.

- analyzed at 95% of helium (mass fraction) in the core
- very massive models: strongly enricht and slowly rotating due to mass loss
- quasi-chemical homogeneous evolution for the whole main sequence only occurs for rapidly rotating models

Summary

- very massive rotating models (60-500 $M_\odot$; 0-550 km/s) are presented which are affected by rotational mixing and mass loss
- mass loss significant for chemical homogeneous evolution and enhancement of elements at the surface
- models evolve close to the Eddington limit
- we show a region in the Hertzsprung-Russell diagram were no stars are predicted
- models evolve further than Humphreys-Davidson limit
- in comparision to VFTS: quantify rotational mixing, overshooting and mass loss for very massive models