Massive Stars Mass Loss

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Mass Loss - Why is it important ...

... for the stellar structure?
- Evolutionary timescale
- Final fate (BH, NS or WD?)
- Structure (CSM) and appearance (WR)

... for the environment?
- chemical and dynamical evolution of Galaxies
- trigger star formation
- blow bubbles
Mass Loss - Possible Driving Mechanisms

Metal Line Driving

Winds

Dynamical Instabilities

LBVs, Episodic Mass Loss, Super-Eddington winds

Binary interactions

Roche Lobe Overflows

Figure: η Car, false colors, from wikipedia.
Parametric models with large uncertainties (clumpiness, non-wind mass loss) encapsulated in efficiency factor:

\[ \dot{M}(L, \text{Teff}, Z, R, M, ...) \]
\[ \downarrow \]
\[ \eta \dot{M}(L, \text{Teff}, Z, R, M, ...) \]

**Figure:** From Smith 2014, ARA&A, 52, 487S
Grid of $Z_\odot$ stellar models:

- Initial mass:
  
  \[ M_{\text{ZAMS}} = \{15, 20, 25, 30, 35\} \, M_\odot; \]

- Efficiency:
  
  \[ \eta = \{1, \frac{1}{3}, \frac{1}{10}\} ; \]

- Different combinations of wind mass loss rates for “hot”, “cool” and WR stars:
  
Example: 25 $M_{\odot}$, $Z_{\odot}$ from ZAMS to O depletion

\[ \log_{10} \left( \frac{t_{\text{O depl}} - t}{\text{yr}} \right) \]
Example: 25 $M_\odot$, $Z_\odot$ from ZAMS to O depletion
Mass Loss - Conclusions

- Mass loss is important both for the stellar structures and their environment;
- Several mass loss mechanisms, hard to implement in stellar evolution codes;
- Large theoretical and observational uncertainties on the mass loss rate $\dot{M}$;
- Effects of these uncertainties unexplored in a systematic way.

Thank you for your attention.