WR Stars in the Galaxy and the LMC: Analyses, Parameters, and Evolution

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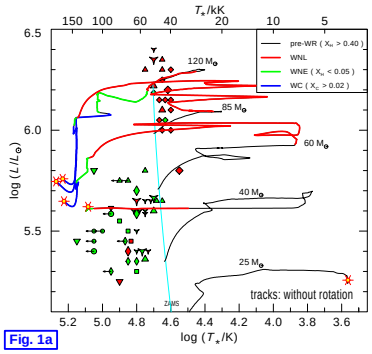

Fig. 1a

How do massive stars evolve? - an empirical proof of the *Conti scenario*

Evolutionary tracks predict (Meynet & Maeder 2003):

- For ZAMS mass above some threshold, stars become Wolf-Rayet (WR) after a red excursion
- For even higher ZAMS mass, the LBV domain is entered before or between WR stages
- Very massive stars evolve directly from O to Wolf-Rayet stars
- The threshold masses differ, depending on whether rotation is neglected (Fig. 1a) or taken into account (Fig. 1b)
- Discrete symbols: analyses of the Galactic WN stars (Hamann et al. 2006)

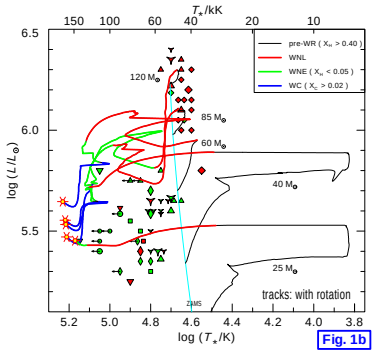

Fig. 1b

The Galactic WN sample: - empirical versus synthetic population

- Empirical HRD of Galactic WN (Fig. 2b): two disjunct groups, distinguishable by their hydrogen content **(first noticed by Conti, Leep & Perry 1983)**
  - WN-late (WNL, red) with hydrogen, very luminous
  - WN-early (WNL, green) hydrogen-free, less luminous
- Synthetic population (Salpeter IMF, constant SFR) from tracks *without* rotation (Fig. 2a):
  - No WR stars from 25 M$_\odot$, low-L WNE *not* reproduced
  - Number WNL:WNE:WC roughly 1:1:2 as observed
- Synthetic population *with* rotation (Fig. 2c):
  - lower luminosities better reproduced
  - Number WNL:WNE:WC roughly 5:1:2 *not* as observed

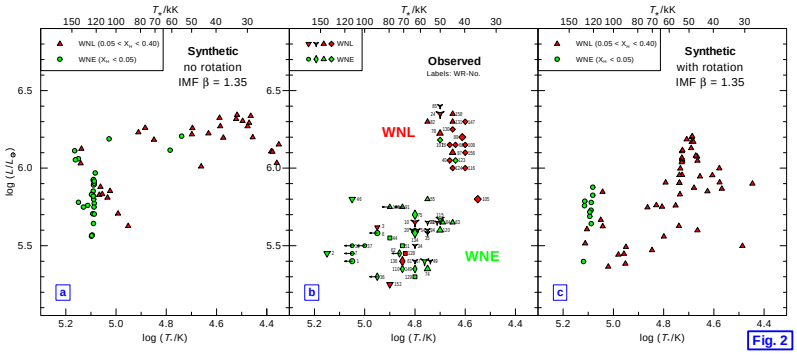

Fig. 2

Are the Galactic WN parameters biased from the distance uncertainties?

- Only 18 galactic single WN stars have known distances from cluster / association membership (others are usually "calibrated" according to their subtype)
- **Here we restrict the sample to stars with known distance**
- In the restricted sample, only 4 from 18 stars belong to WNL stars with very high luminosity (log L > 6.0)
- The restricted sample populates the same regions of the HRD (Fig. 3b) as the full sample (cf. Fig. 2b) → same conclusions:
  - The synthetic population *without rotation* does not produce the low-luminous WNE stars
  - The synthetic population *with rotation* does not produce enough WNE, i.e. hydrogen-free stars

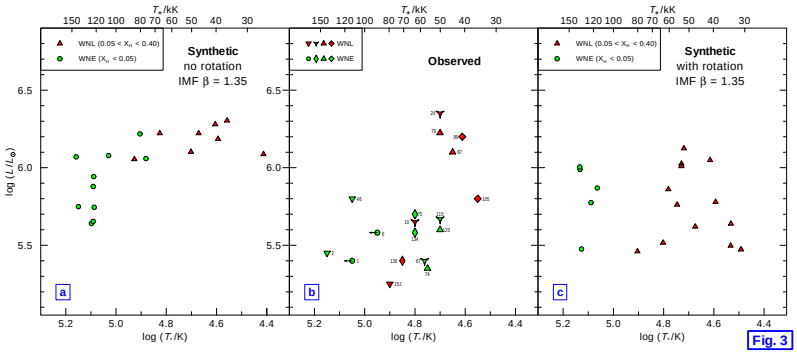

Fig. 3

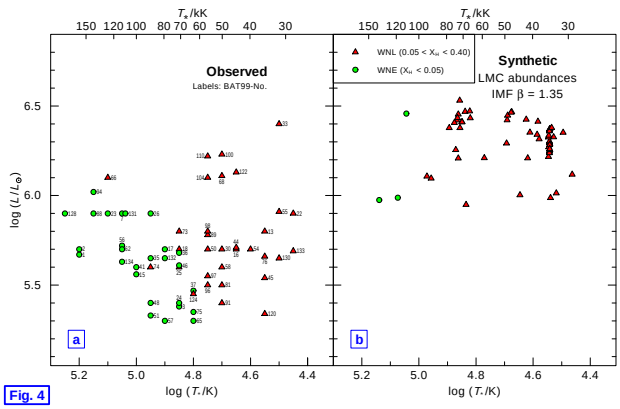

Fig. 4

Another test case: the WN population in the LMC

- New analyses of the complete WN sample (108 stars) in the LMC with line-blanketed Potsdam Wolf-Rayet (PoWR) models (Hamann et al., in prep.)
- Reliable luminosities, because the distance is known !
- 59 single WN stars, after omitting all suspected or confirmed binaries
- Comparison to the Galactic WN population (see Fig. 4a vs. Fig. 2b):
  - Similar regions of the HRD populated
  - Same number ratio between WNL / WNE about 1:1 (with / without hydrogen)
  - In the LMC, many WNL have only moderately high luminosity
- Comparison with evolutionary calculations
  - Tracks for LMC-metallicity (Z = 0.08), no rotation (Schaerer et al. 1993) yield no WR stars for initial masses of 25 and 40 M$_\odot$
  - Correspondingly, the synthetic population based on the LMC-tracks (Fig. 4b) predicts only very bright WNL, and almost no WNE
  - Comparison of the LMC sample with tracks for *Galactic metallicity* (see above figures) suffers from same problems as the Galactic sample

Conclusions: - The evolution of massive stars is still not well understood
- Where is the metallicity effect ?