Massive stars in the Galactic center

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Outline

1 Motivation
   • Massive stars

2 Stellar Winds
   • Basic ideas
   • Model atmospheres

3 The Quintuplet Cluster
   • The Galactic Center region
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   • Massive evolved stars
1 Motivation
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Massive stars

- initial mass $M_{\text{init}} > 8 \, M_\odot$ (> 20 \, M_\odot!)
- CNO cycle is dominant nuclear process
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$$25M_\odot < M_{\text{init}} < 60M_\odot :$$
- O $\rightarrow$ Of $\rightarrow$ RSG or LBV $\rightarrow$ WN 8 $\rightarrow$ WNE $\rightarrow$ WC $\rightarrow$ SN
Massive stars

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- CNO cycle is dominant nuclear process

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- $O \rightarrow O_f \rightarrow$ RSG or LBV $\rightarrow$ WN 8 $\rightarrow$ WNE $\rightarrow$ WC $\rightarrow$ SN

$> 60M_\odot$:
- $O \rightarrow O_f \rightarrow$ WNL + abs $\rightarrow$ WN 7 ($\rightarrow$ WNE) $\rightarrow$ WC $\rightarrow$ SN
Why are massive stars important?

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  → trigger/terminator for star formation
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KEY PLAYERS in COSMIC RECYCLING!
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Stellar winds

- Castor, Abbott and Klein - CAK theory 1975
  radiative pressure on spectral lines in the atmosphere
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- Nugis & Lamers 2000:
  WN stars $\dot{M} \sim L^{1.7}$
Observational evidence - P Cygni line profiles

$I_+^\nu$ (cont)

$I_+^\nu$ (core rays)

$I_+^\nu$ (non-core)
Observational evidence - P Cygni line profiles

$I^+_\nu (cont)$

$I^+_\nu (core rays)$

$I^+_\nu (non-core)$

Flux $F_\nu$

Wavelength $\lambda$

+ 

= 

Adriane Liermann (Potsdam University)
observed stellar winds:

- A and B supergiants - absorption lines (Kudritzki!)
- O/Of stars - emission lines + UV resonance lines as P Cygni
- WR stars - emission lines + P Cygni
PoWR - Potsdam Wolf-Rayet code for expanding atmospheres (Hamann et al.)

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  \[ v(r) = v_\infty \left(1 - \frac{r_0}{r}\right)^\beta \]
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⇒ radiative transfer in non-LTE
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- velocity field: \( v(r) = v_\infty \left(1 - \frac{r_0}{r}\right)^\beta \)
  
  \( \Rightarrow \) radiative transfer in non-LTE

\( \Rightarrow \) model grids
Fitting an emission line spectrum

Hamann et al. 2006
Fitting a spectral energy distribution

Hamann et al. 2006

DM=12.55 mag  E_{b-v}=0.24  shift=1.05 dex  CARDELLI 3.10
M_v = -7.05 mag  6.49  6.43  6.097  6.012  5.816
WR024

log F_λ [erg s^{-1} cm^{-2} Å^{-1}]

log λ [Å]
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The Galactic Center

- accessible by IR and radio observations
- 3 young massive stellar clusters: Arches, Quintuplet, Central cluster
- stellar population: massive stars!
The Quintuplet Cluster

- (super)massive cluster $\sim 10^4 M_\odot$
- 30 pc projected distance from GC (Okuda et al. 1989, 1990)
- 4 Million years old (Figer et al. 1999)
- cluster radius about 1 pc

- named after 5 prominent (back then featureless) stars
The Observations

- ESO SINFONI-SPIFFI (no AO)
- 22 target fields of $8 \times 8$ arcsec FOV
- K grating (1.95 - 2.45 $\mu$m)
The Quintuplet Cluster

Massive evolved stars

(backgroundColor: HST image, PI D. Figer, STScI)
The Catalog


- 160 flux-calibrated $K$-band spectra
- 98 early-type stars
- 62 late-type stars
- synthetic $K_s$ photometry
160 stars
Photometric completeness

![Histogram of Ks magnitudes](image-url)
Massive stars in the Quintuplet

- evolved stars: 4 WN stars & 9 WC stars (6 WN and 10 WC in total)

⇒ to be analyzed with PoWR code:
  fit emission line spectra
  fit spectral energy distribution
  derive stellar parameters
Thanks for your attention