I Zw 18 + Chem.hom.ev. stars?

Dorottya Szécsi

XShootU Prague 2023

It all started with Sara Heap…

who told Norbert Langer, who told me…

and then Carolina came along:

THE ASTROPHYSICAL JOURNAL LETTERS, 801:L28 (6pp), 2015 March 10 doi:10.1088/2041-8205/801/2/L28

THE EXTENDED He II λ4686-EMITTING REGION IN IZw 18 UNVEILED: CLUES FOR PECULIAR IONIZING SOURCES

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ABSTRACT

New integral field spectroscopy has been obtained for IZw 18, the nearby lowest-metallicity galaxy considered to be our best local analog of systems forming at high redshift (z). Here we report the spatially resolved spectral map of the nebular He II λ4686 emission in IZw 18, from which we derived for the first time its total He II-ionizing flux. Nebular He II emission implies the existence of a hard radiation field. He II-emitters are observed to be more frequent among high-z galaxies than for local objects. Therefore, investigating the He II-ionizing source(s) in IZw 18 may reveal the ionization processes at high z. He II emission in star-forming galaxies has been suggested to be mainly associated with Wolf–Rayet stars (WRs), but WRs cannot satisfactorily explain the He II-ionization at all times, particularly at the lowest metallicities. Shocks from supernova remnants, or X-ray binaries, have been proposed as additional potential sources of He II-ionizing photons. Our data indicate that conventional He II-ionizing sources (WRs, shocks, X-ray binaries) are not sufficient to explain the observed nebular He II λ4686 emission in IZw 18. We find that the He II-ionizing radiation expected from models for either low-metallicity

He-II ionization in IZw18 (NW region)

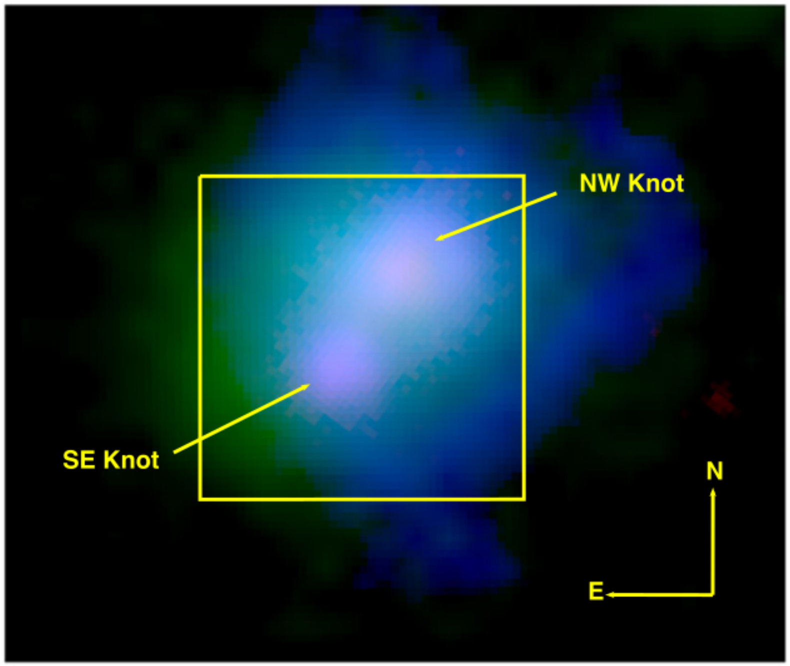
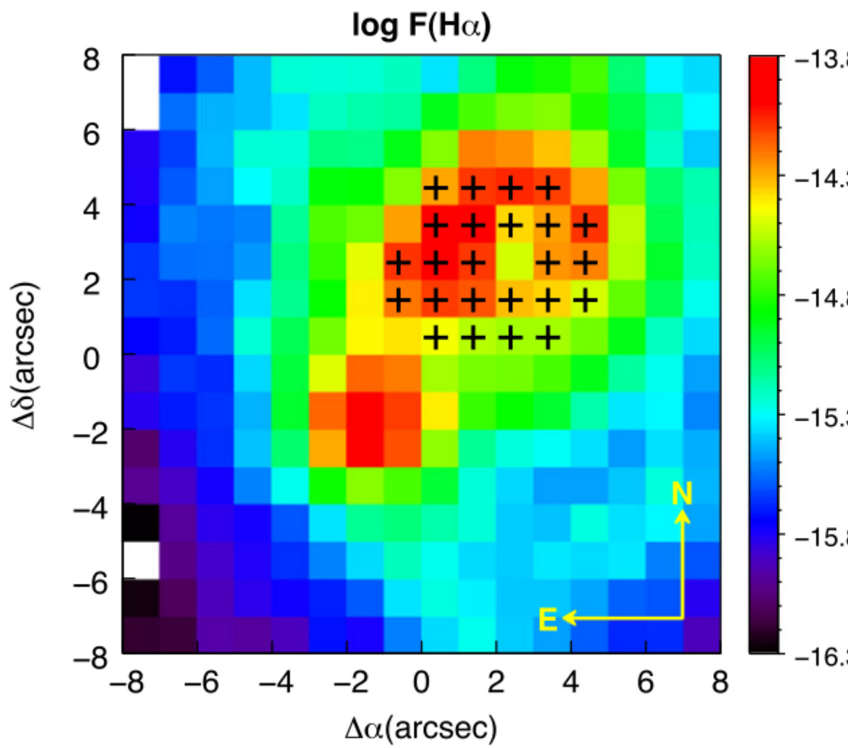


Figure 1. Color-composite image of IZw 18 (blue = Hα from Palomar, green = far-UV/*GALEX*, red = SDSS r'). The box represents the FOV (16"×16") of the PMAS spectrograph over the galaxy main body and the extended Hα halo. The PMAS FOV is centered on the coordinates R.A. (J2000.0) = 09^h:34^m:$02^s.2$ and decl. (J2000.0) = +55°:14′:25″.



A&A 581, A15 (2015)
DOI: 10.1051/0004-6361/201526617

Astronomy & Astrophysics

Low-metallicity massive single stars with rotation

Evolutionary models applicable to I Zwicky 18⋆,⋆⋆

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ABSTRACT

Context. Low-metallicity environments such as the early Universe and compact star-forming dwarf galaxies contain many massive stars. These stars influence their surroundings through intense UV radiation, strong winds and explosive deaths. A good understanding of low-metallicity environments requires a detailed theoretical comprehension of the evolution of their massive stars.
Aims. We aim to investigate the role of metallicity and rotation in shaping the evolutionary paths of massive stars and to provide

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Astronomy & Astrophysics

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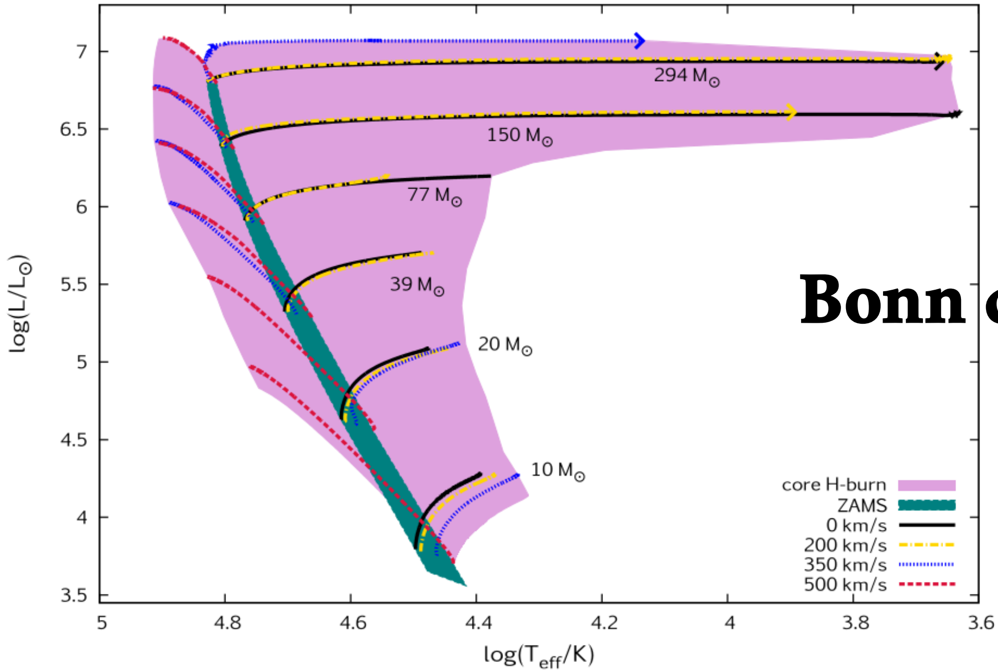


Fig. 5. Evolutionary tracks in the HR diagram during core hydrogen burning for models with initial masses between 9–300 $M_\odot$ (see labels) and initial rotational velocities of 0, 200, 350 and 500 km s^{-1}, with a composition of 1/10 Z_{SMC}. The lighter (purple) shading identifies the region in which all models of our grid undergo core hydrogen burning. The darker (green) shading identifies the zero-age main-sequence. An arrow marks the end of the tracks for models that were stopped before the terminal age main-sequence was reached. Core-hydrogen-burning objects are expected to be found on both sides of the ZAMS, inside the purple coloured region.

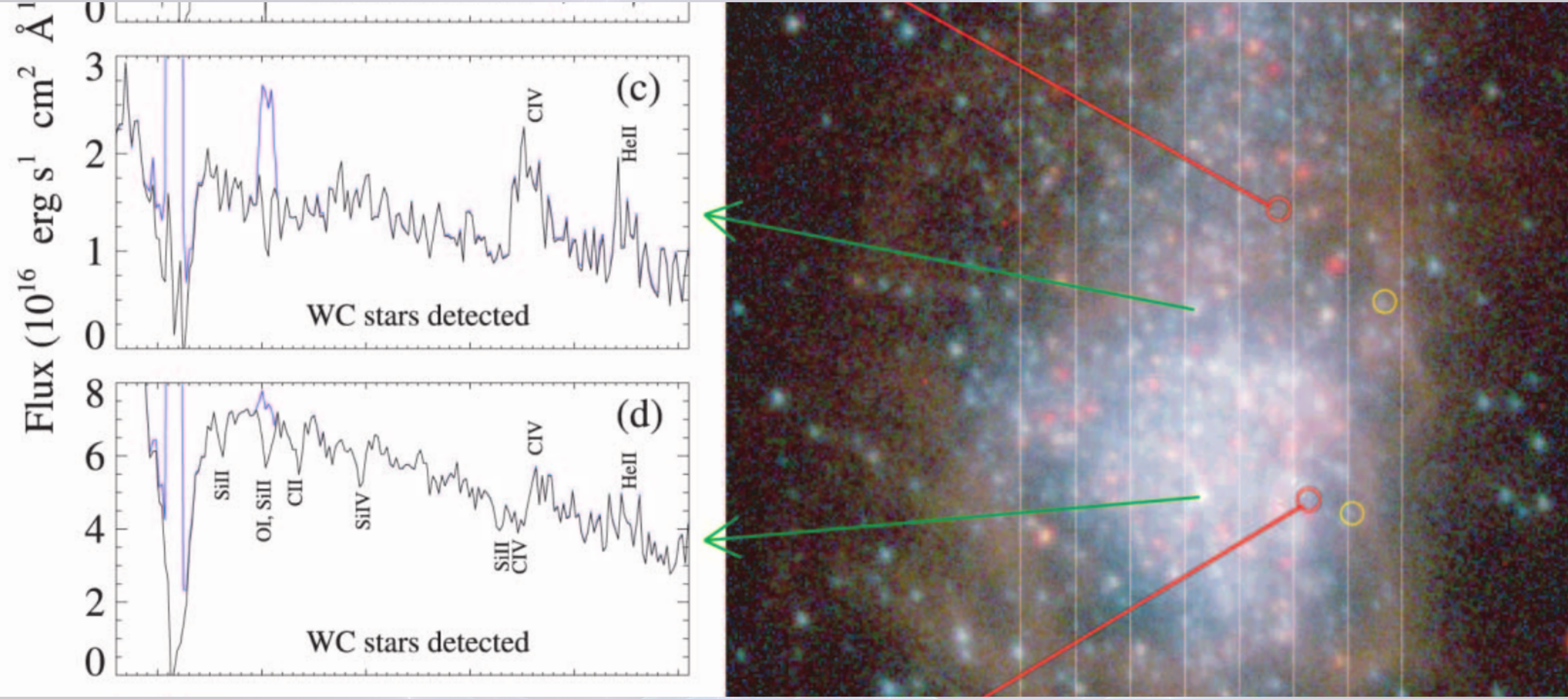
Bonn code

[1] Argelander-I…
e-mail: doro…
[2] Department … Korea
[3] Astronomica…
[4] UK Astrono…

Received 27 M…

Context. Low-… many massive stars. These stars influence their surroundings through intense UV radiation, strong winds and explosive deaths. A good understanding of low-metallicity environments requires a detailed theoretical comprehension of the evolution of their massive stars.
Aims. We aim to investigate the role of metallicity and rotation in shaping the evolutionary paths of massive stars and to provide

There are ***some*** WCs…



Brown+02

Brankica came along…

The "TWUIN collaboration"

A&A 623, A8 (2019)
https://doi.org/10.1051/0004-6361/201834360

Astronomy & Astrophysics

Low-metallicity massive single stars with rotation

II. Predicting spectra and spectral classes of chemically homogeneously evolving stars

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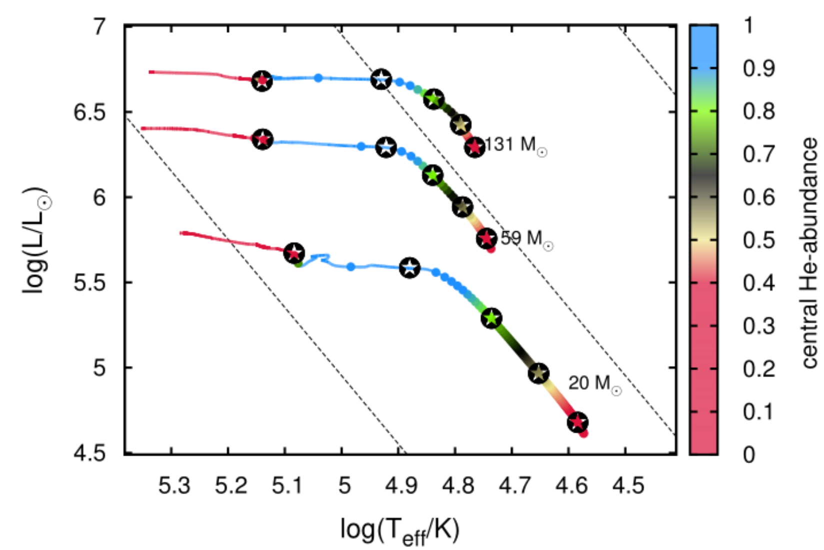


Fig. 1. HR diagram of our models (black symbols) and their corresponding evolutionary sequences. The sequences are taken from Paper I and Szécsi (2016). Initial masses are labeled, showing where the tracks start their evolution, proceeding toward the hot side of the diagram. Colors show the central helium mass fraction, and dots represent every 10^5 years of evolution. Dashed lines mark equiradial lines with 1, 10, and 100 $R_\odot$ from left to right. The black symbols represent the models for which we computed synthetic spectra. From right to left: black symbols correspond to evolutionary phases with surface helium mass fractions of 0.28, 0.5, 0.75, and 0.98, and the fifth symbol on the very left corresponds to a central helium mass fraction of 0.5, i.e., the middle of the CHeB phase.

PoWR code

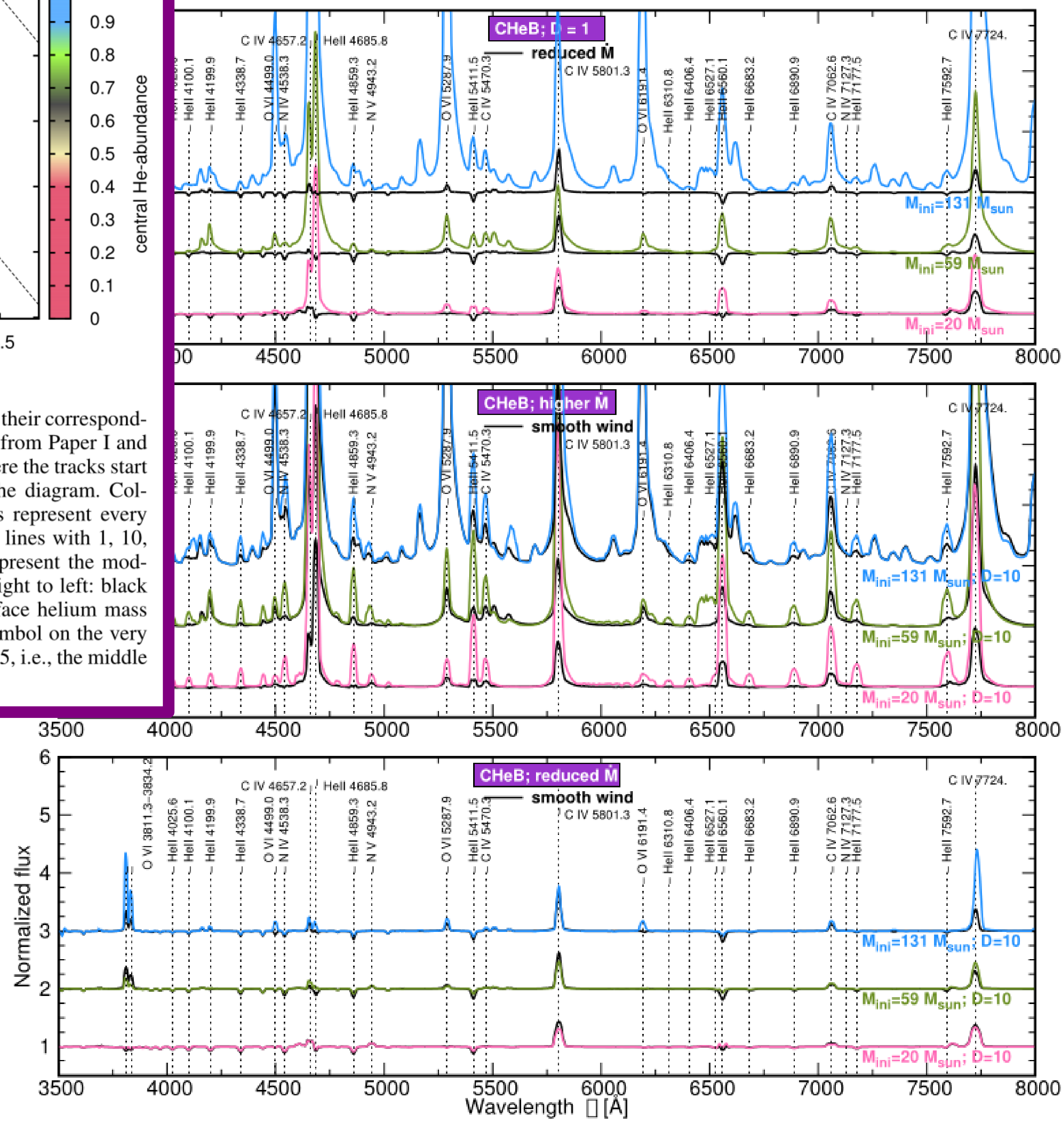
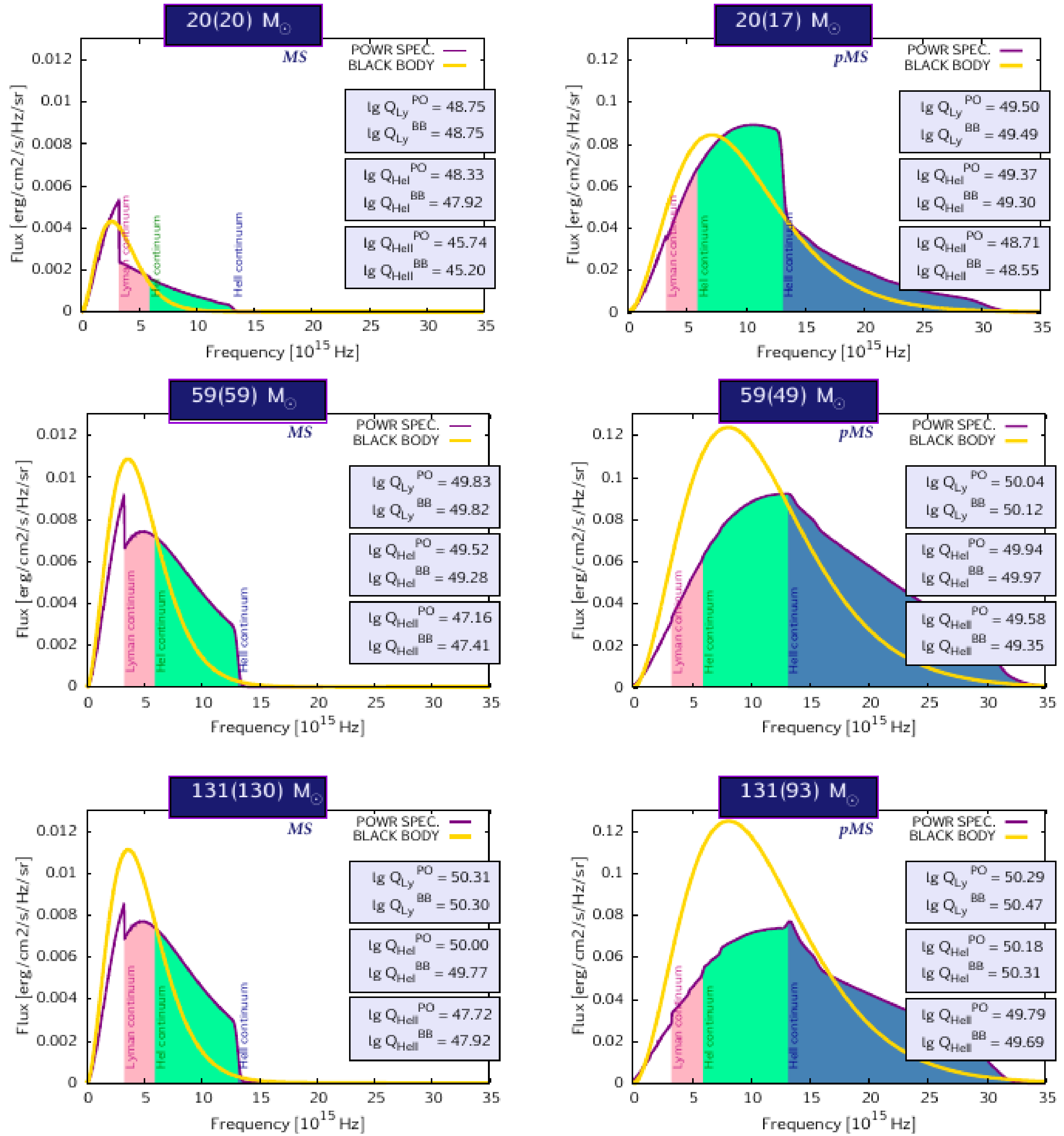
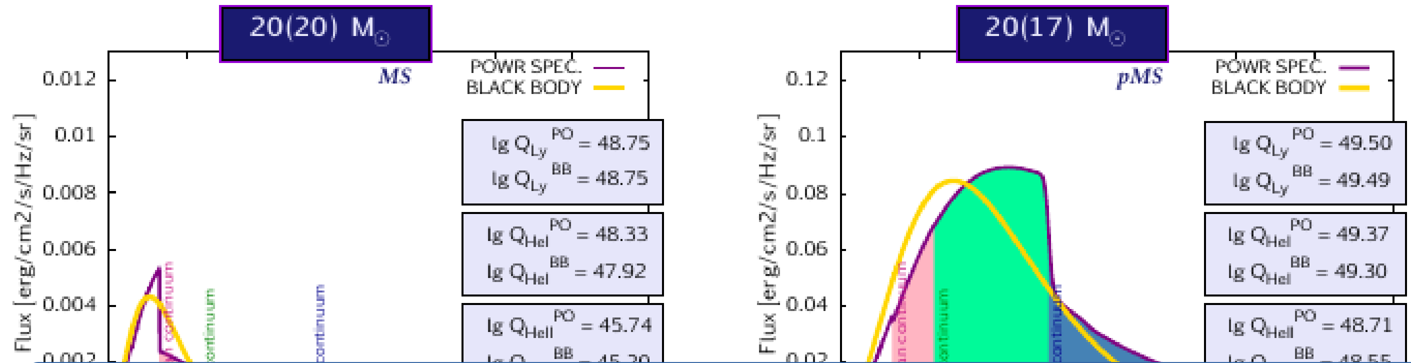


Fig. 4. *Top panel*: same as Fig. 3, but for the CHeB evolutionary phase with Y_s as given in Table 1. *Middle and lowest panels*: same as the top


20(20) $M_\odot$
MS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 48.75$
$\lg Q_{Ly}^{BB} = 48.75$
$\lg Q_{HeI}^{PO} = 48.33$
$\lg Q_{HeI}^{BB} = 47.92$
$\lg Q_{HeII}^{PO} = 45.74$
$\lg Q_{HeII}^{BB} = 45.20$
Lyman continuum
HeI continuum
HeII continuum
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]
20(17) $M_\odot$
pMS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 49.50$
$\lg Q_{Ly}^{BB} = 49.49$
$\lg Q_{HeI}^{PO} = 49.37$
$\lg Q_{HeI}^{BB} = 49.30$
$\lg Q_{HeII}^{PO} = 48.71$
$\lg Q_{HeII}^{BB} = 48.55$
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]
59(59) $M_\odot$
MS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 49.83$
$\lg Q_{Ly}^{BB} = 49.82$
$\lg Q_{HeI}^{PO} = 49.52$
$\lg Q_{HeI}^{BB} = 49.28$
$\lg Q_{HeII}^{PO} = 47.16$
$\lg Q_{HeII}^{BB} = 47.41$
Lyman continuum
HeI continuum
HeII continuum
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]
59(49) $M_\odot$
pMS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 50.04$
$\lg Q_{Ly}^{BB} = 50.12$
$\lg Q_{HeI}^{PO} = 49.94$
$\lg Q_{HeI}^{BB} = 49.97$
$\lg Q_{HeII}^{PO} = 49.58$
$\lg Q_{HeII}^{BB} = 49.35$
HeI continuum
HeII continuum
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]
131(130) $M_\odot$
MS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 50.31$
$\lg Q_{Ly}^{BB} = 50.30$
$\lg Q_{HeI}^{PO} = 50.00$
$\lg Q_{HeI}^{BB} = 49.77$
$\lg Q_{HeII}^{PO} = 47.72$
$\lg Q_{HeII}^{BB} = 47.92$
Lyman continuum
HeI continuum
HeII continuum
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]
131(93) $M_\odot$
pMS
POWR SPEC.
BLACK BODY
$\lg Q_{Ly}^{PO} = 50.29$
$\lg Q_{Ly}^{BB} = 50.47$
$\lg Q_{HeI}^{PO} = 50.18$
$\lg Q_{HeI}^{BB} = 50.31$
$\lg Q_{HeII}^{PO} = 49.79$
$\lg Q_{HeII}^{BB} = 49.69$
HeI continuum
HeII continuum
Flux [erg/cm2/s/Hz/sr]
Frequency [10^{15} Hz]



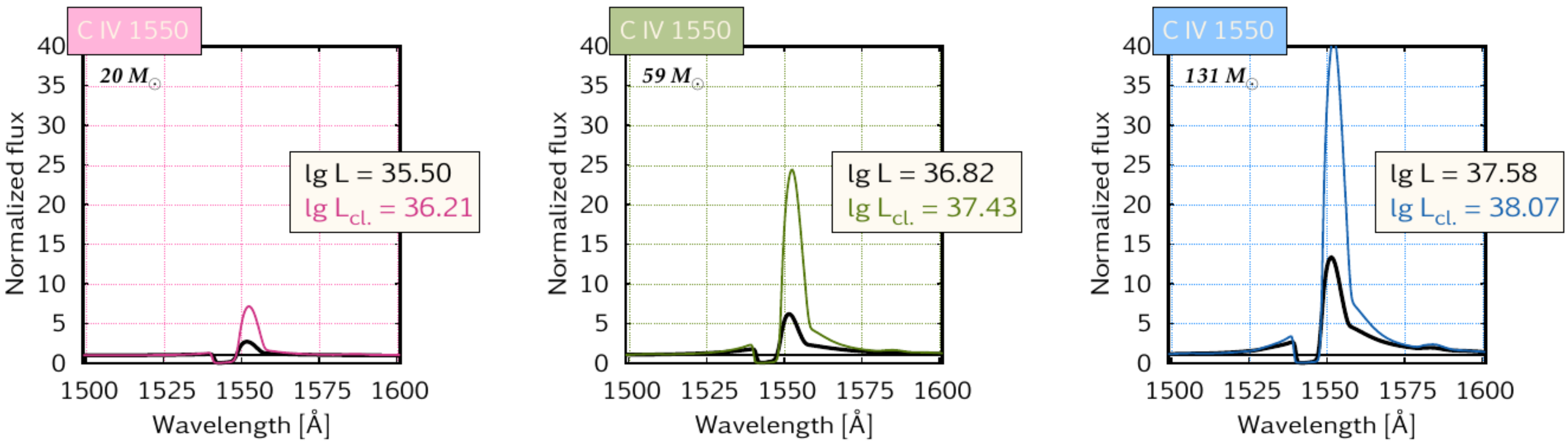
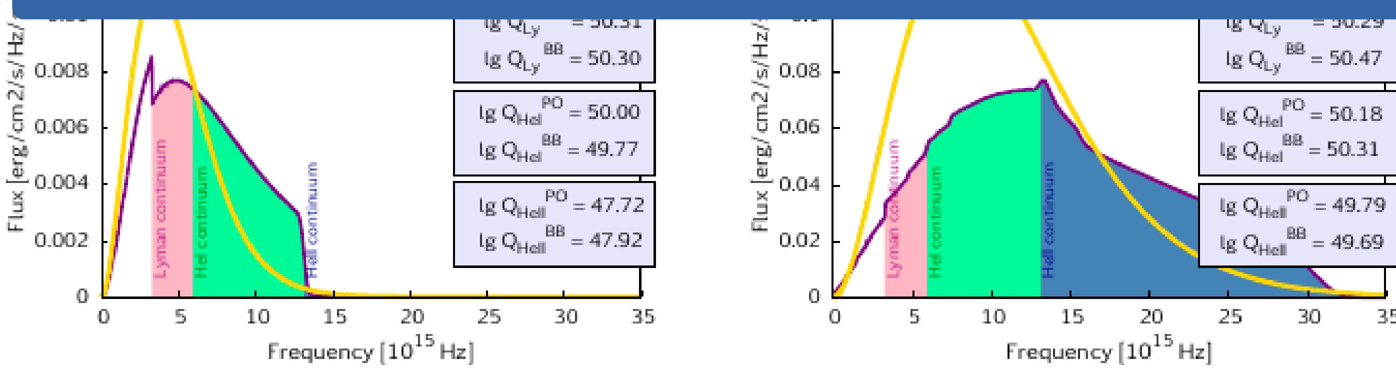


Fig. 3. Normalized flux around the UV-line C IV λ1550 Å in three spectral models with initial masses as indicated in the top left corner of the panels. Line luminosity (computed by integrating the area under the line) is given in the framed boxes in units of log(erg s^{-1}); lg L stands for unclumped (clumping factor D = 1) while lg L_{cl} for clumped (D = 10) wind, see details in Paper II. When creating the synthetic population here (Sect. 2.2 and Sect. 3.1), we always apply the unclumped models' predictions (i.e. black line). Other emission lines are presented in Figs. A.1-A.2.



3rd paper submitted in 2019...

Astronomy & Astrophysics manuscript no. output
April 25, 2019

LETTER TO THE EDITOR

Chemically homogeneously evolving stars as the source of photoionization and C IV emission in dwarf starburst galaxies

Low-metallicity massive single stars with rotation. Part III.

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ABSTRACT

Chemically-homogeneously evolving stars have been proposed to account for several exotic phenomena, including gamma-ray bursts, gravitational wave emissions and certain types of supernovae. Nonetheless, their existence has not yet been observationally proven. Here we provide a new piece of evidence that these stars may indeed exist in nature. In a metal-poor dwarf galaxy, I Zwicky 18,

Referee report

- OIV 3818 ??
- CIV 5808 ??
- CIV 7724 ?
- HeII4686 ?

- **UV** OVI 1037
- HeII 1640, OVI 2070, also CIV 1550… ?????

...explain all available observations from the literature

No one knows if CHE stars exist…

- GW (-emitting compact object) progenitors
- lGRB progenitors
- supernova Ib/c
- …

direct observations missing!!

Basically looking for the parent stars of Gravitational Waves...

What to do if you don't know stg?

What to do if you don't know stg?

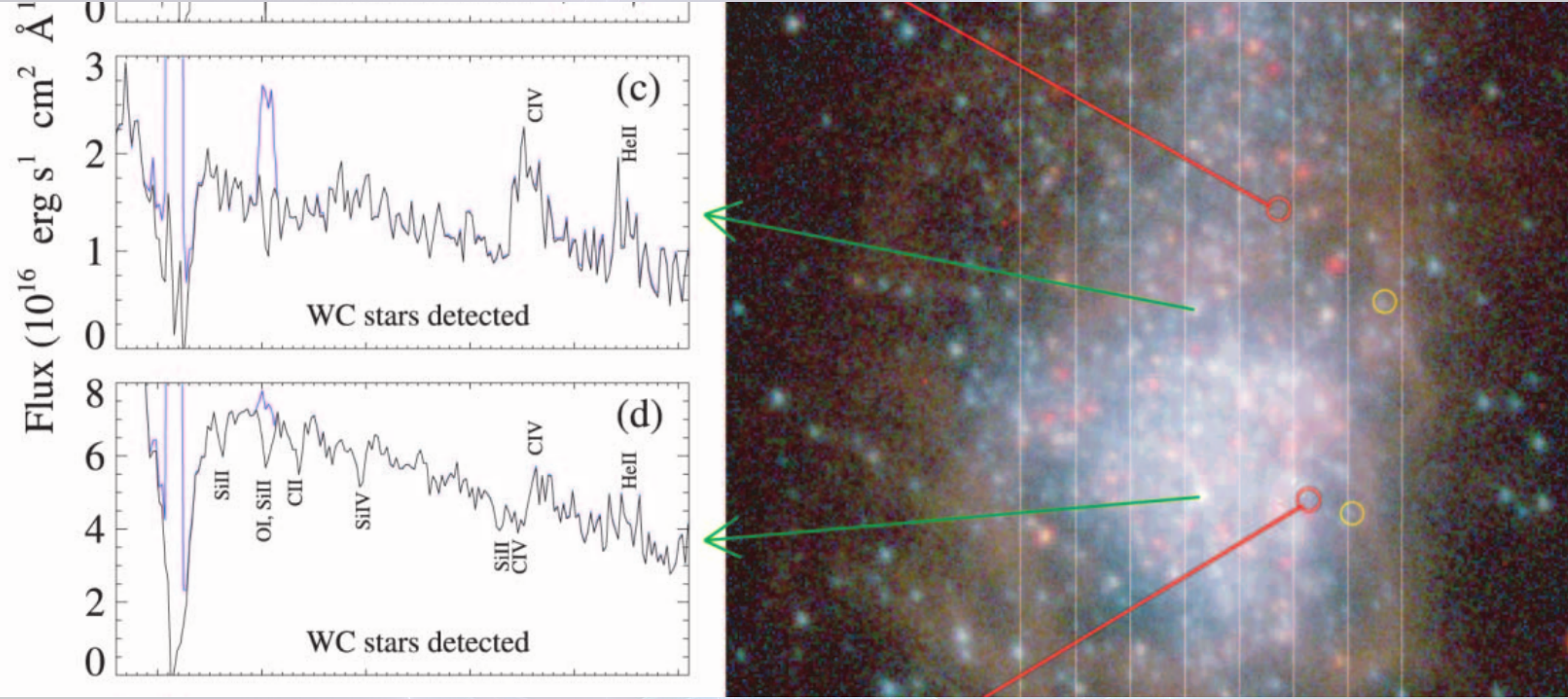
- ASK FOR HELP

What to do if you don't know stg?

- ASK FOR HELP

Enter 2023…

What to do if you don′t know stg?



- OIV 3818 ✓
- CIV 5808 ✓
- CIV 7724 ✓?
- HeII4686 ✓

- **UV** OVI 1037 ✓
- HeII 1640 ✓
  OVI 2070 ✓?
  CIV 1550 ✓

Appendix A: Line luminosities

Figures A.1 and A.2 show the various optical and UV emission lines discussed in Sect. 3.3.

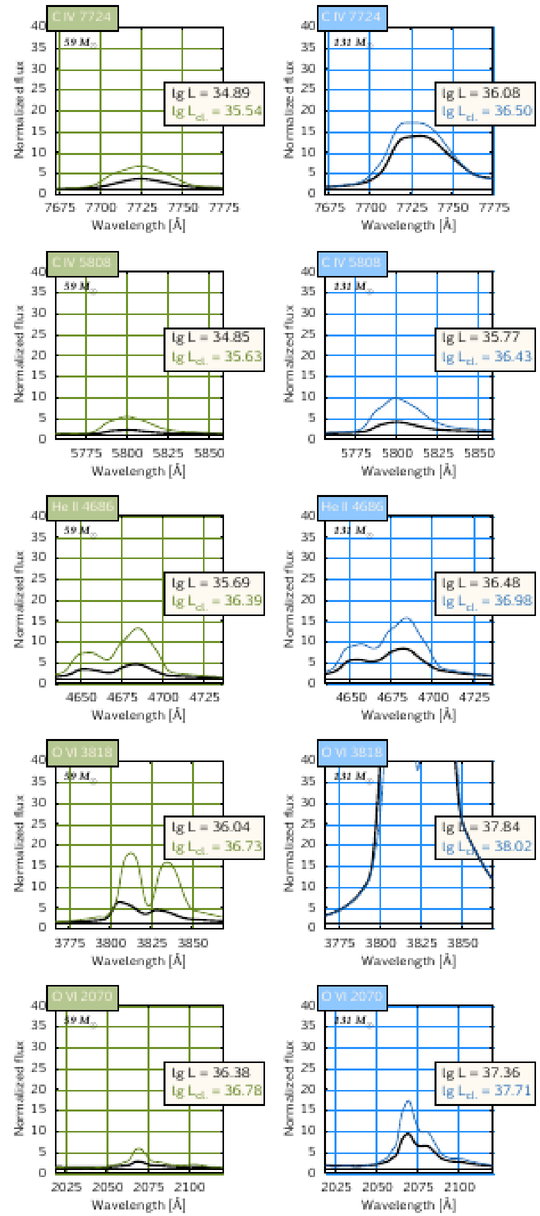


Fig. A.1. Optical emission lines predicted by our massive (M_{ini} = 59 $M_\odot$) and very massive (M_{ini} = 131 $M_\odot$), chemically-homogeneously evolving, post-main-sequence models (classified as WO stars in this phase by Paper II; during the main-sequence evolutions, they were classified as early O type stars). In our ficucial population (Sect. 2.2), one or two such very massive stars are present with >110 $M_\odot$; in our alternative population (Sect. 3.1), about six such stars with ~40 $M_\odot$ and one with ~90 $M_\odot$ are present, accounting for

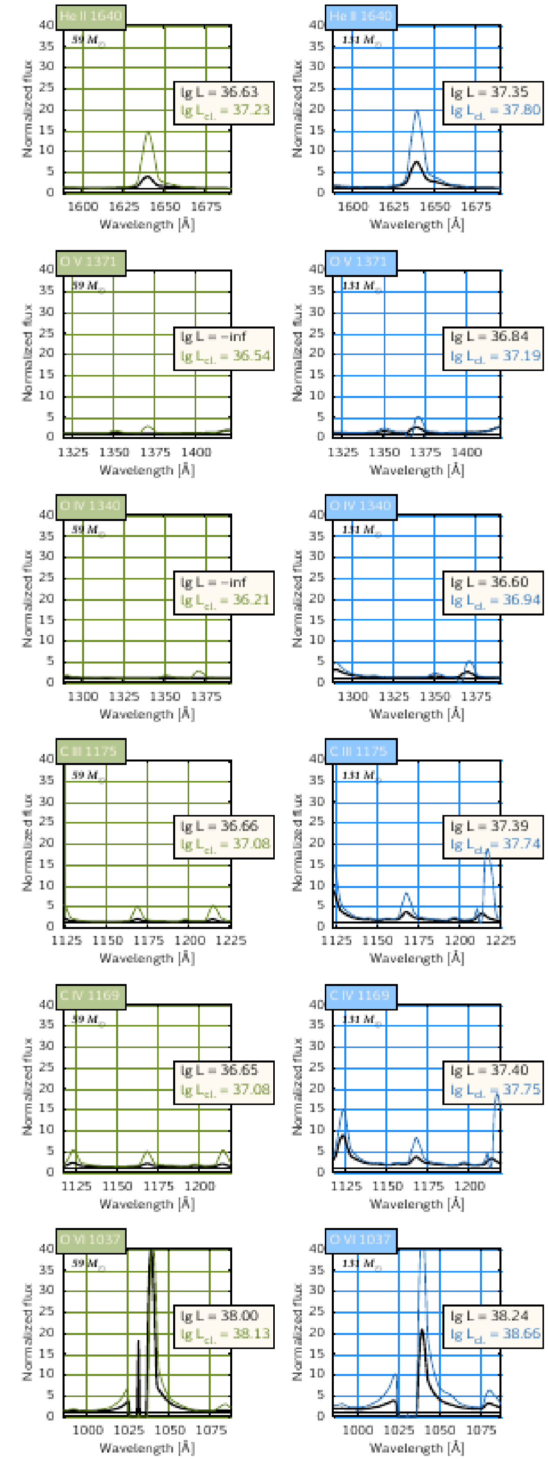


Fig. A.2. UV emission lines predicted by our models. See Fig. A.1. Note that we always apply the unclumped models' predictions (i.e. black line).