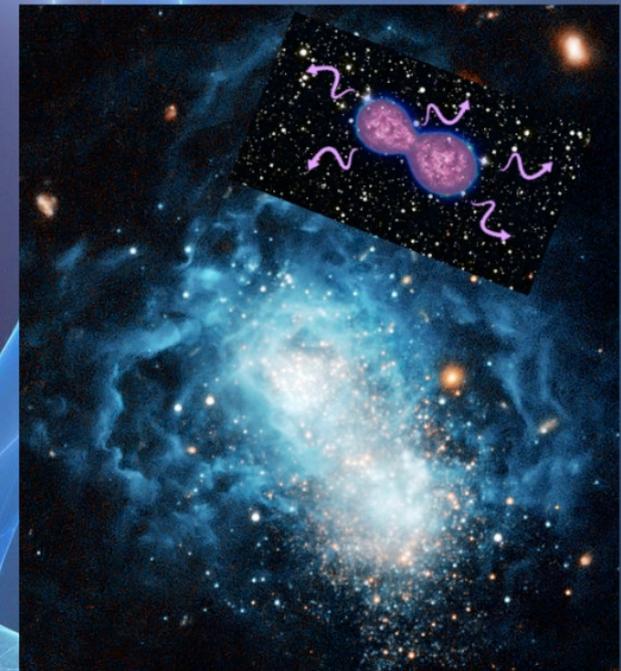


Does I Zwicky 18 harbor GW progenitors?

The story of a dwarf galaxy
and what I learned in the past 12 years

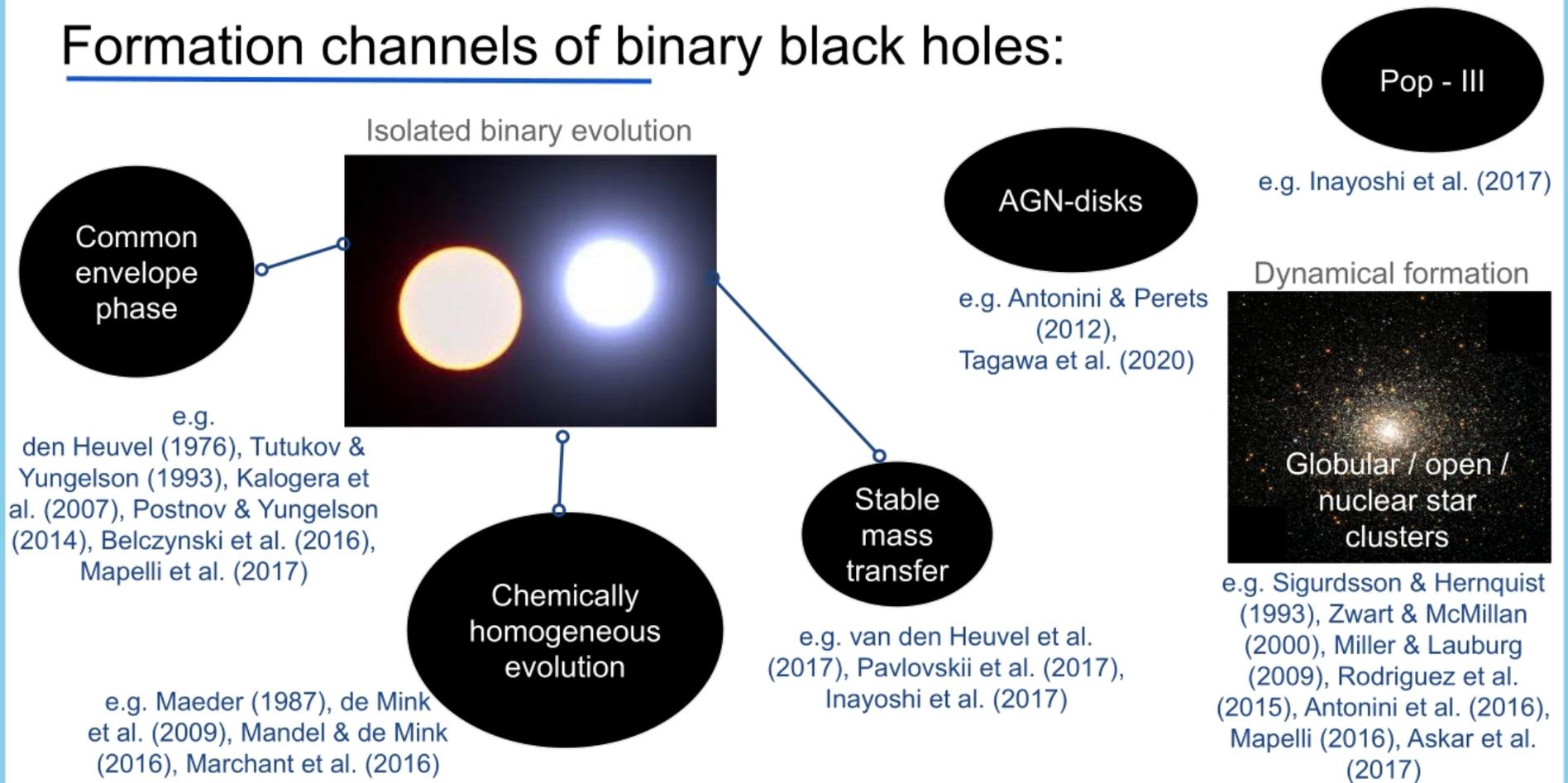
Dorottya Szécsi

Nicolaus Copernicus University



**Ortvay Colloquium
ELTE, Budapest, 9 Oct. 2025**

Formation channels of binary black holes:



Credit for slides: R. Sarwar

Formation channels of binaries

Isolated binary evolution

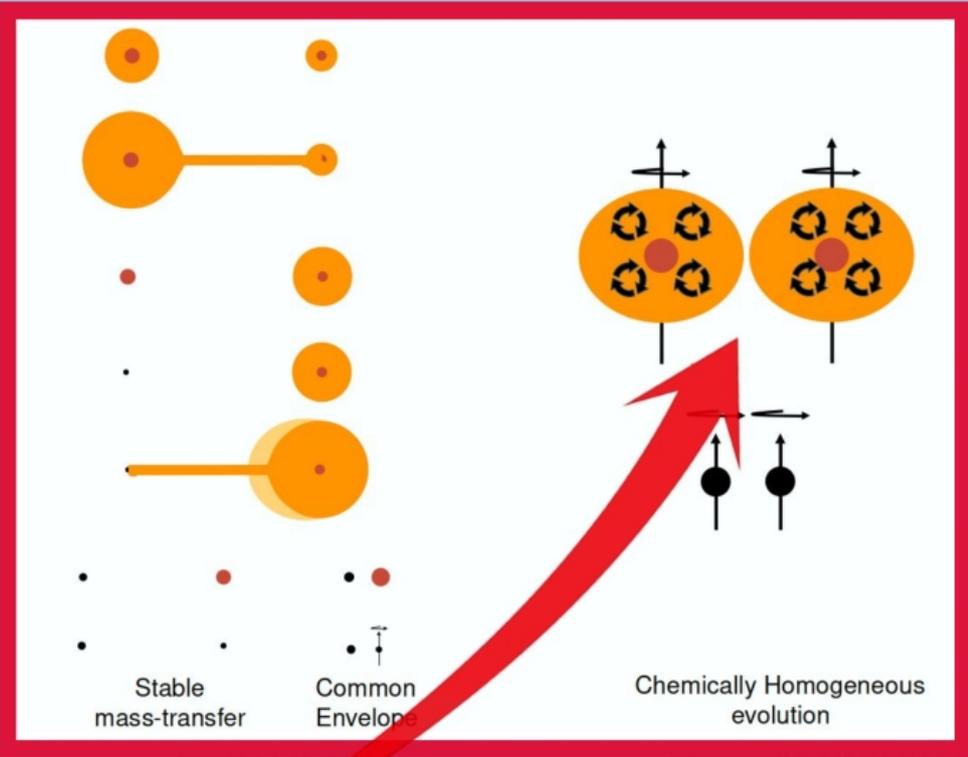
Common envelope phase



e.g. den Heuvel (1976), Tutukov & Yungelson (1993), Kalogera et al. (2007), Postnov & Yungelson (2014), Belczynski et al. (2016), Mapelli et al. (2017)

Chemically homogeneous evolution

e.g. Maeder (1987), de Mink et al. (2009), Mandel & de Mink (2016), Marchant et al. (2016)



Stable mass transfer

e.g. van den Heuvel et al. (2017), Pavlovskii et al. (2017), Inayoshi et al. (2017)

Chemically Homogeneous evolution

nuclear star clusters

e.g. Sigurdsson & Hernquist (1993), Zwart & McMillan (2000), Miller & Lauburg (2009), Rodriguez et al. (2015), Antonini et al. (2016), Mapelli (2016), Askar et al. (2017)

Dr. habil. Dorottya Szécsi, prof. UMK

Associate Prof. &
OPUS group leader



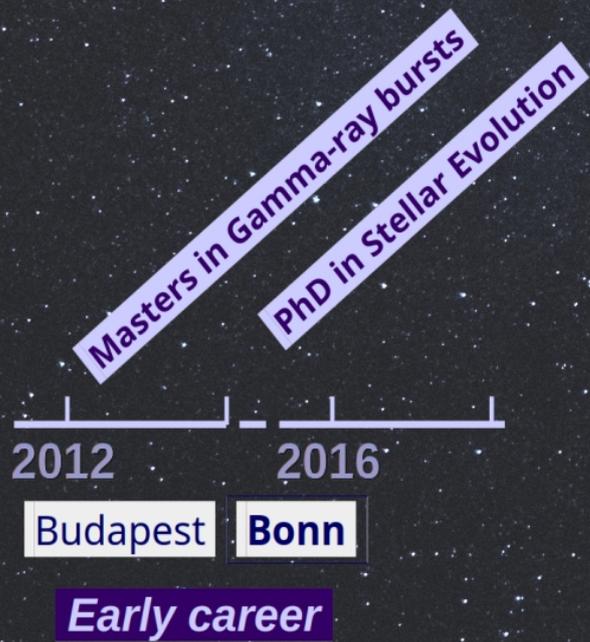
Dr. habil. Dorottya Szécsi, prof. UMK

How did I get myself into this?

Associate Prof. &
OPUS group leader



Dorottya Szécsi



Left Budapest wanting to do a

PhD in “something theoretical”

(but preferably connected to GRBs)

Left Budapest wanting to do a

PhD in “something theoretical”

(but preferably connected to GRBs)

BONN (GERMANY)

*PhD (2012-16):
The evolution
of low-metallicity
massive stars*

Advisor: Norbert Langer



“massive stars”: $>8 M_{\odot}$

“evolution”:
computational stellar
evolution (1D)

“low-metallicity”:
~metal content of the
dwarf galaxy **I Zwicky 18**
~ $1/50 Z_{\odot}$
~ $1/10 Z_{\text{SMC}}$
[Fe/H] ~ -1.7

PhD (2012-16):
The evolution
of low-metallicity
massive stars

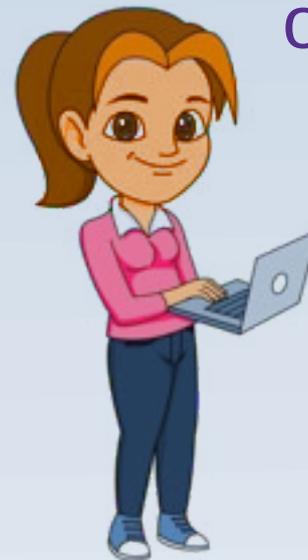
“massive stars”: $>8 M_{\odot}$

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[Fe/H] ~ -1.7



PhD (2012-16):
The evolution
of low-metallicity
massive stars



He-II ionization in IZw18 (NW region)

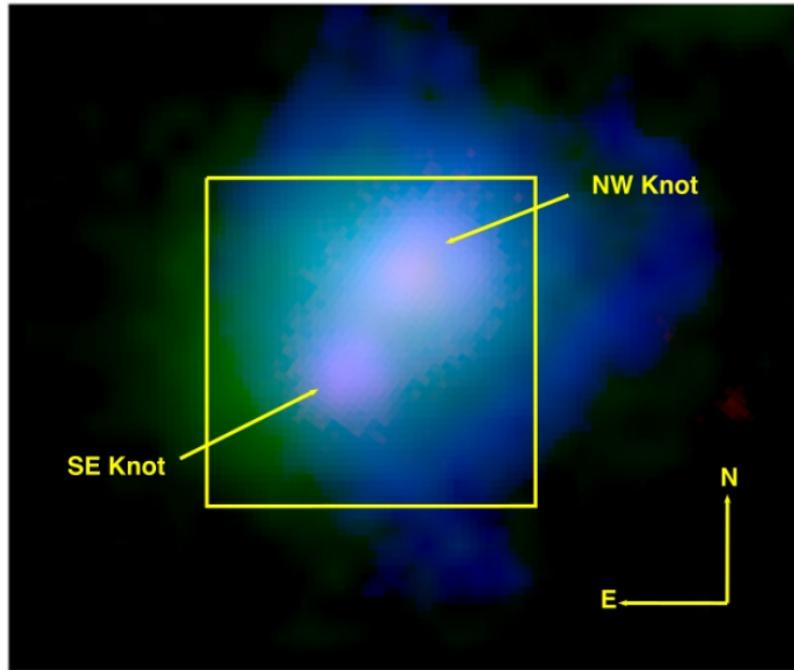
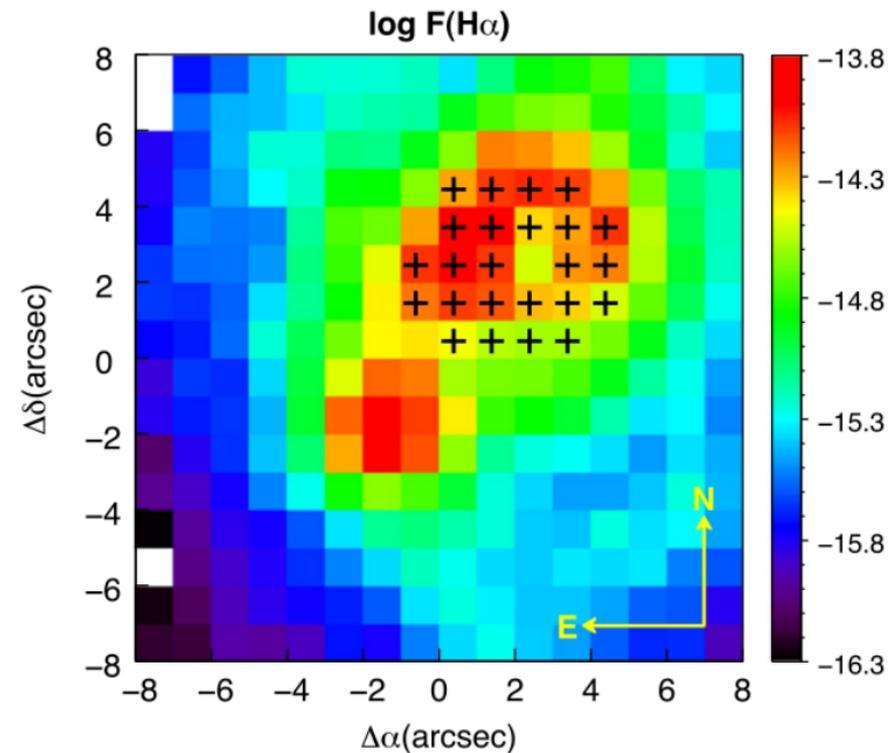
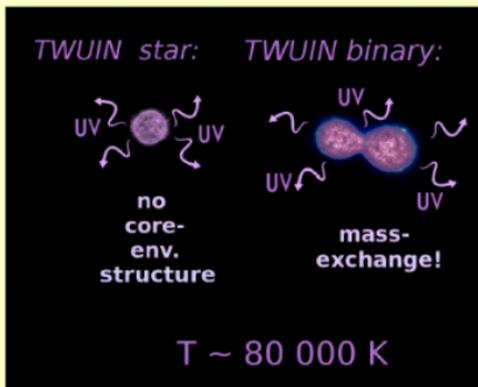
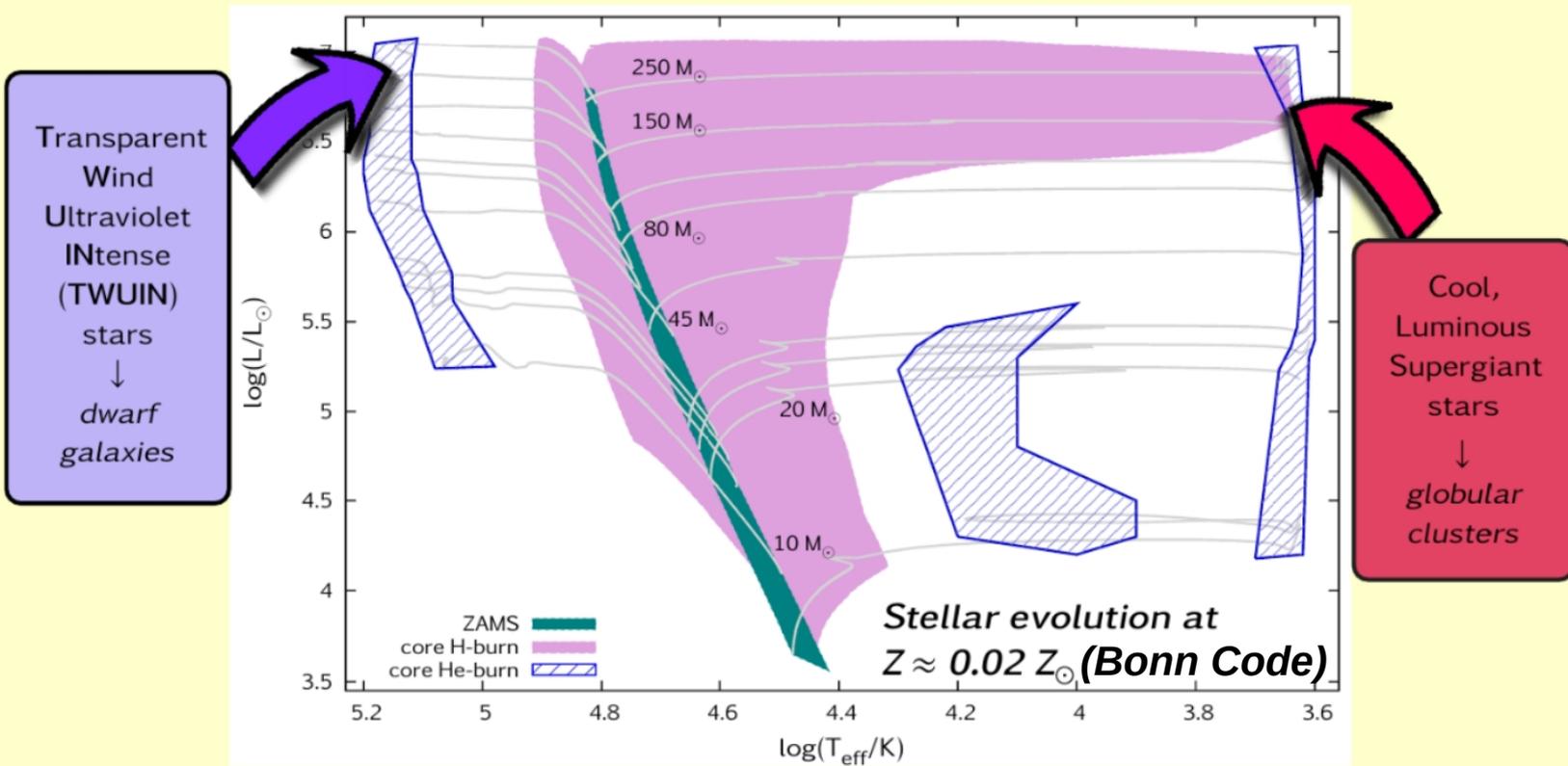


Figure 1. Color-composite image of IZw 18 (blue = $H\alpha$ from Palomar, green = far-UV/*GALEX*, red = SDSS r'). The box represents the FOV ($16'' \times 16''$) of the PMAS spectrograph over the galaxy main body and the extended $H\alpha$ halo. The PMAS FOV is centered on the coordinates R.A. (J2000.0)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

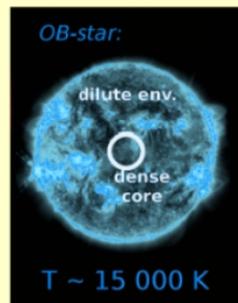


Credit: Kehrig+15

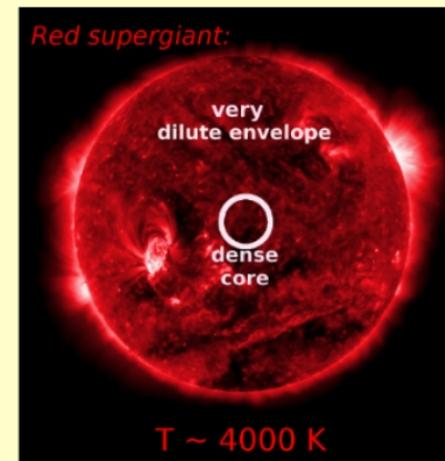
Summary of my PhD:



Kubátová & Szécsi+19, Szécsi'17a,'17b



Szécsi+22, Garcia, ..., Szécsi+21



Szécsi & Wunsch'19, Szécsi+18

BUT.

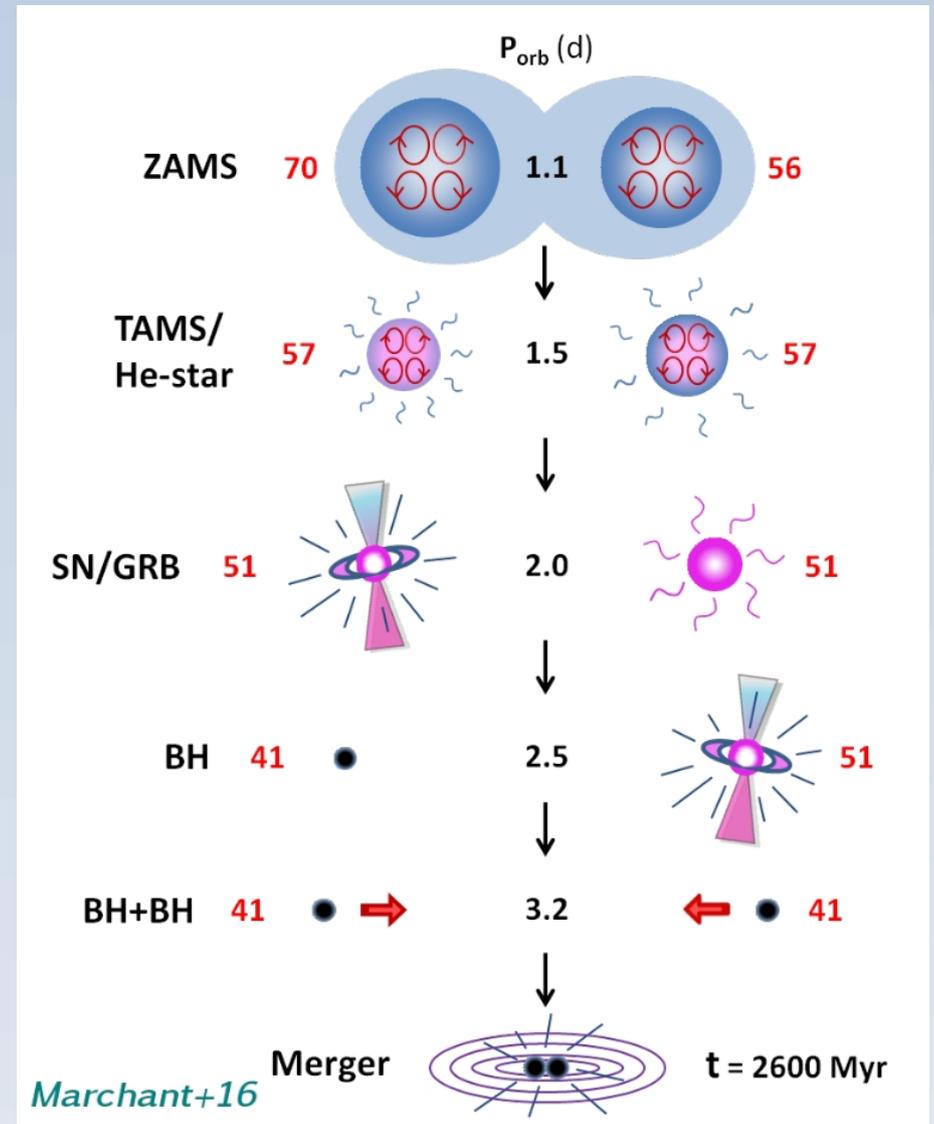
- Offering *an* explanation is not the same thing as *proving the existence of*, right?

In 2016...

- First GW observed by LIGO/Virgo announced! And...

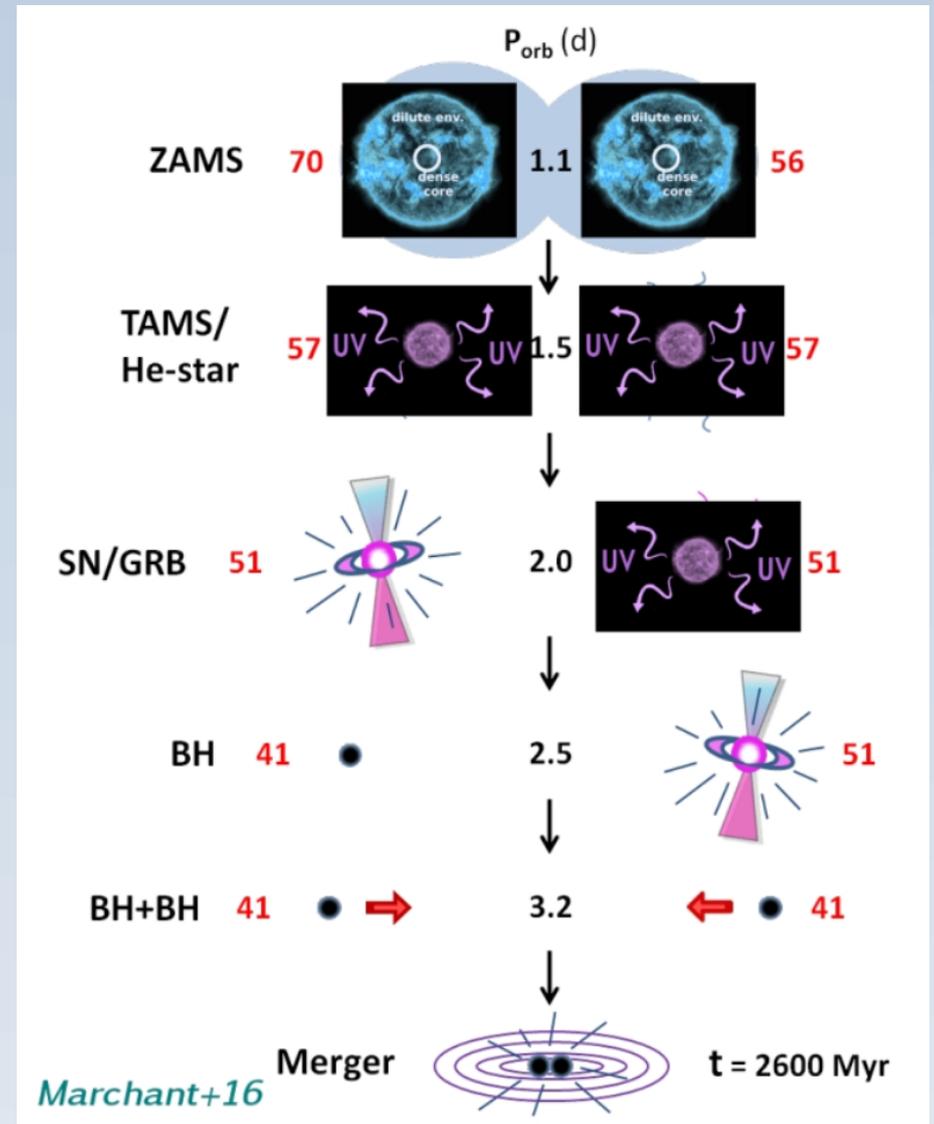
In 2016...

- First GW observed by LIGO/Virgo announced! And...



In 2016...

- First GW observed by LIGO/Virgo announced! And...

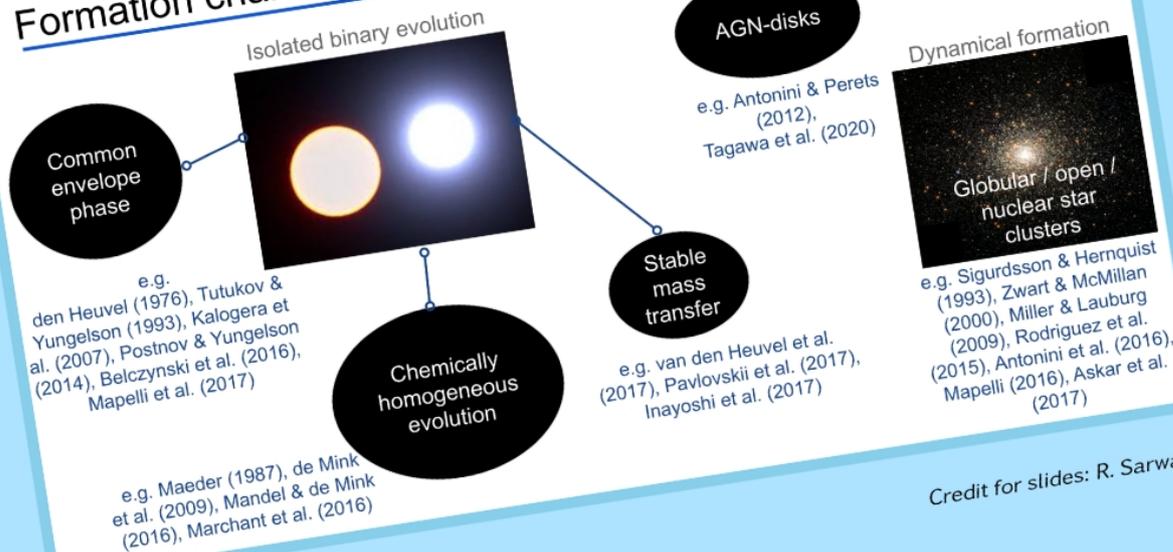


In 2016

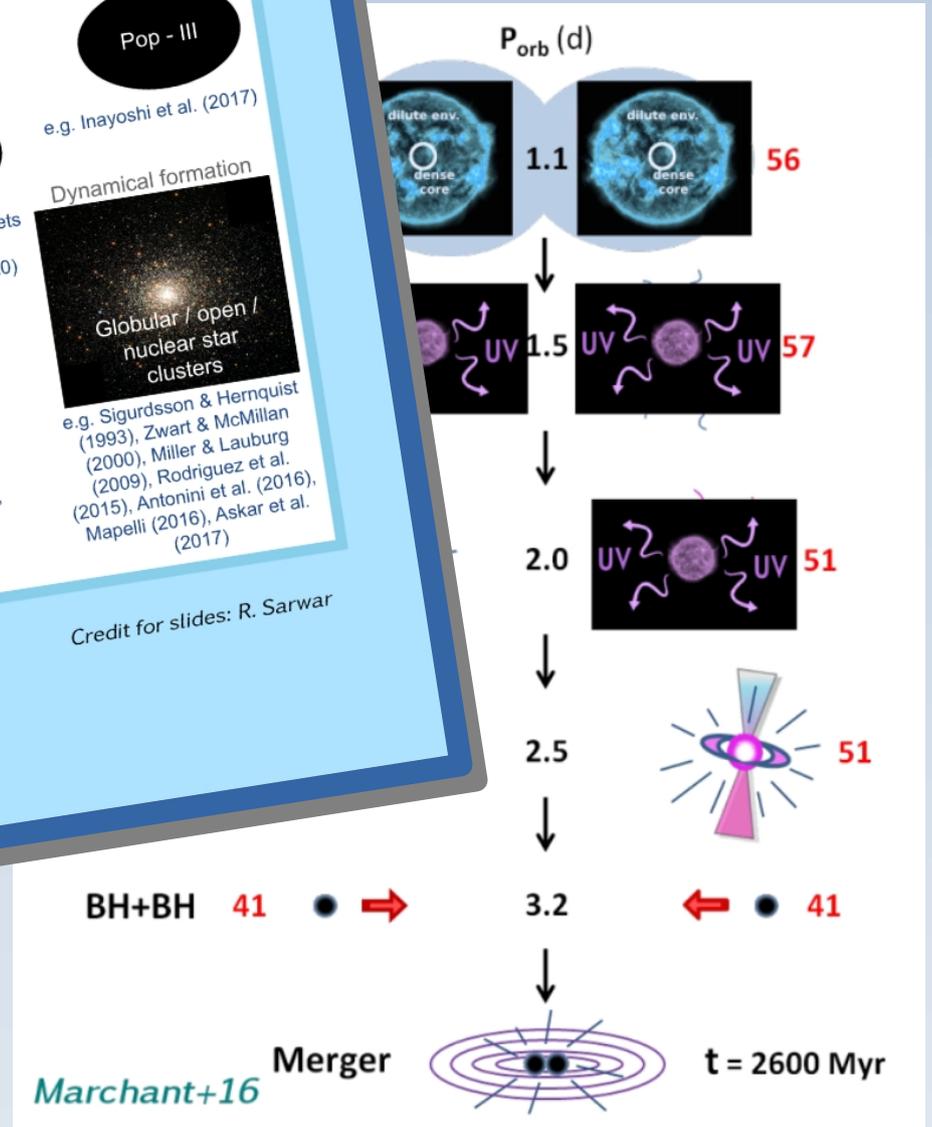
• First GW

Virgo

Formation channels of binary black holes:



Credit for slides: R. Sarwar

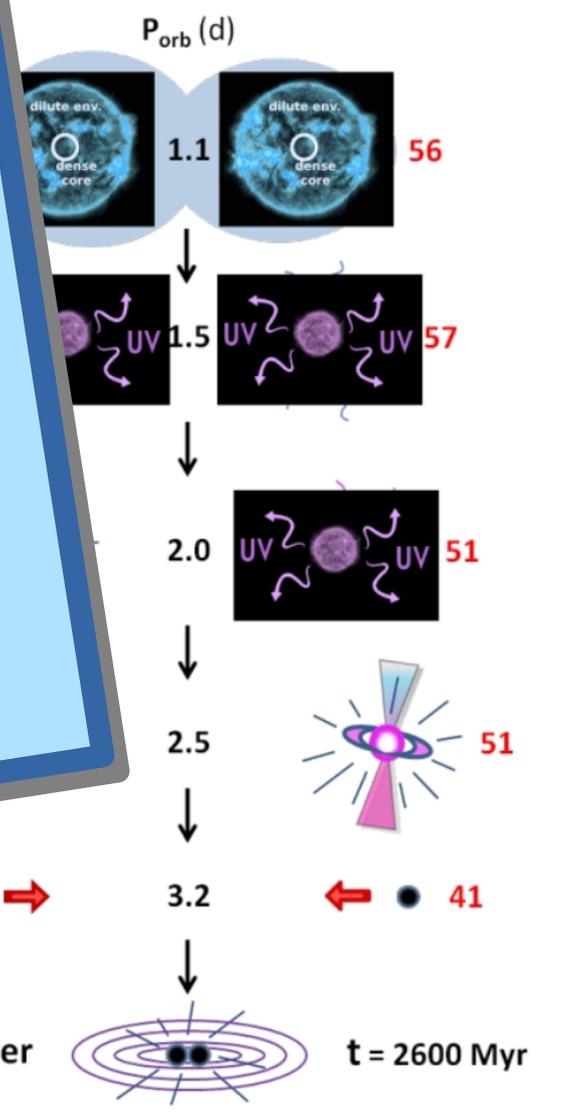
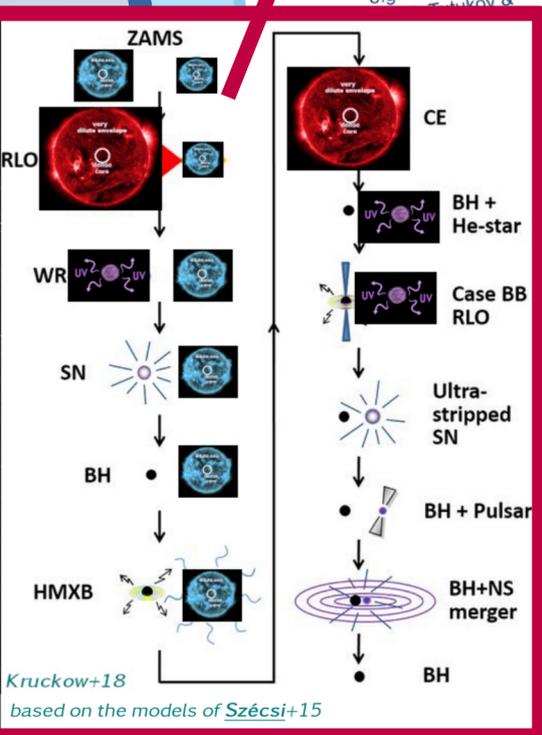
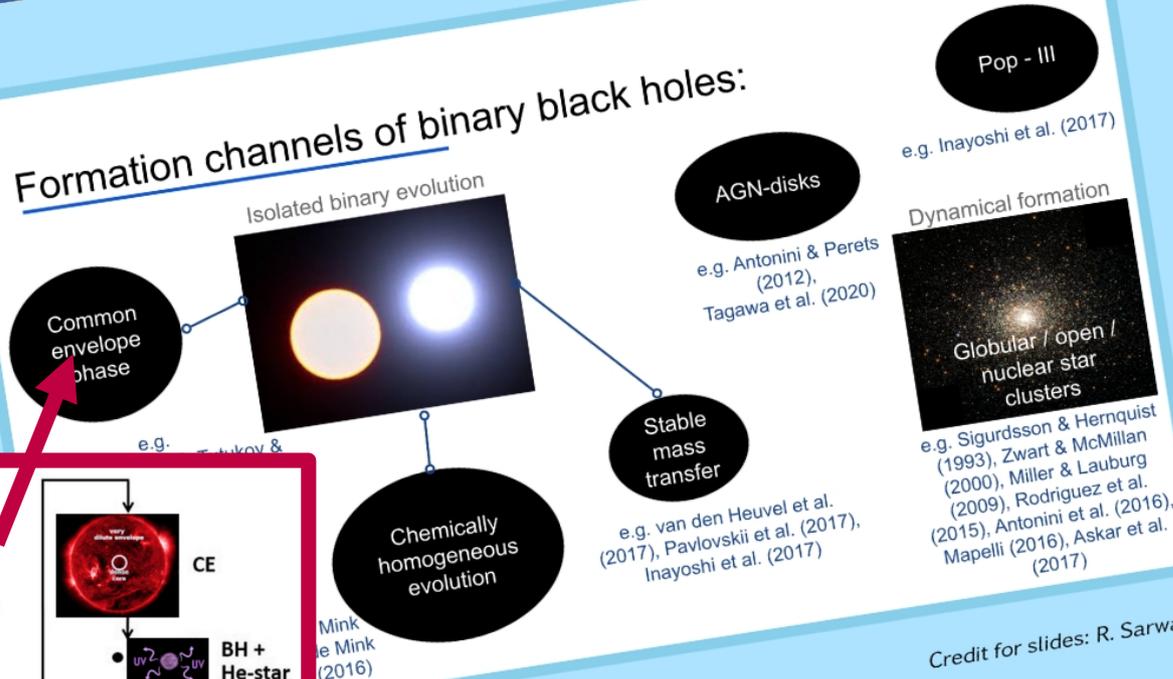


In 2016

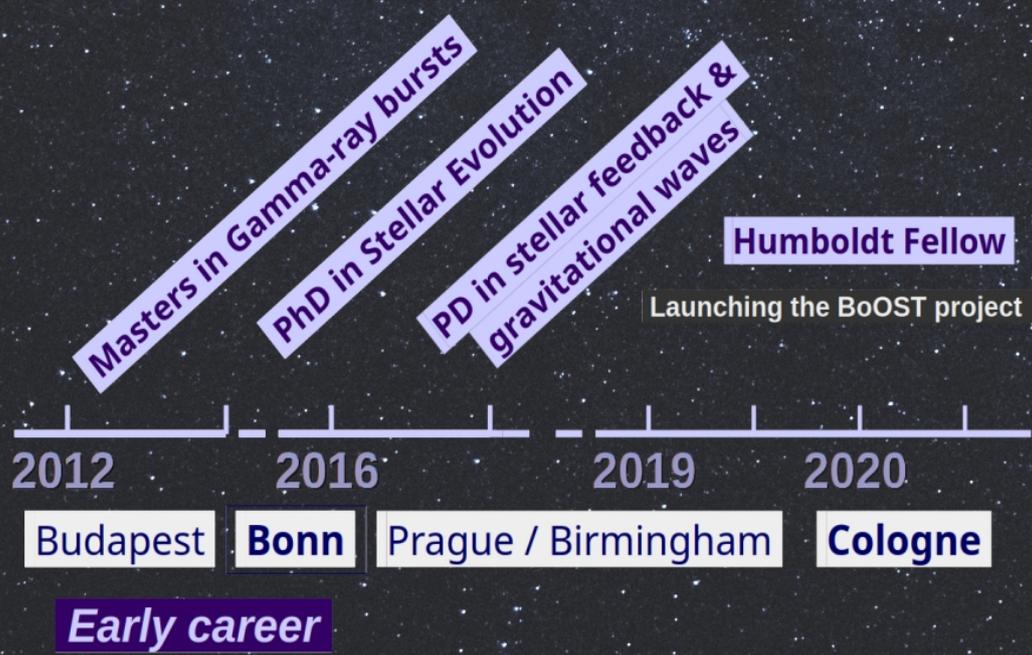
• First GW

Virgo

Formation channels of binary black holes:

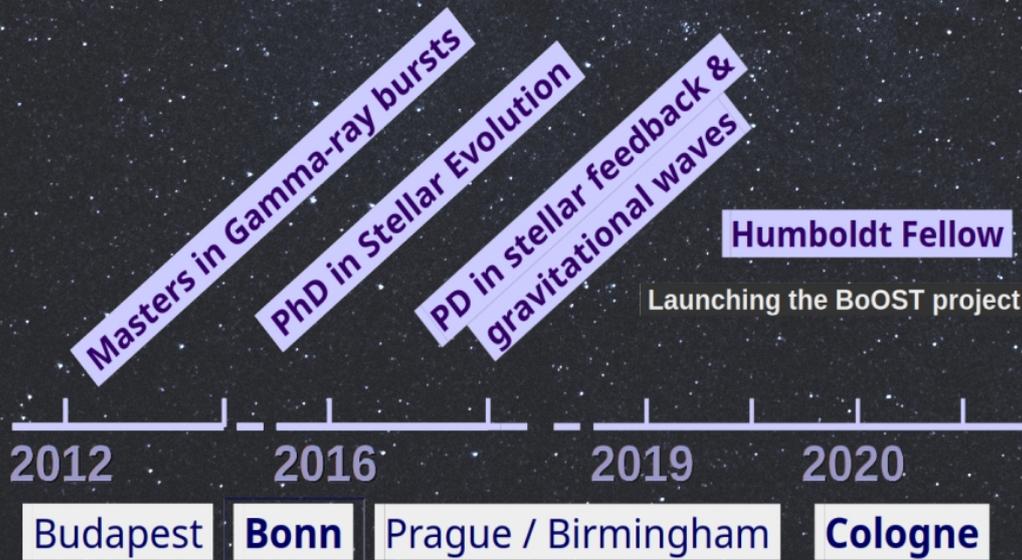


Dr. Dorottya Szécsi,



Dr. Dorottya Szécsi,

Post-doc
challenge...
PROVE THEM



Early career

What else do we know about I Zw 18?

- WR galaxy

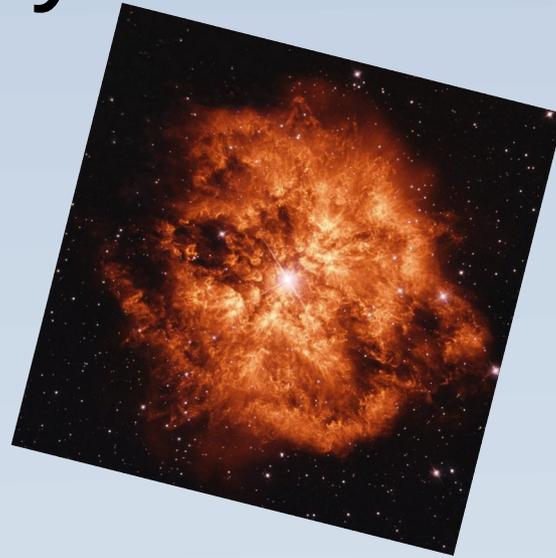
What else do we know about I Zw 18?

- WR galaxy



What else do we know about I Zw 18?

- WR galaxy
=contains
Wolf–Rayet stars



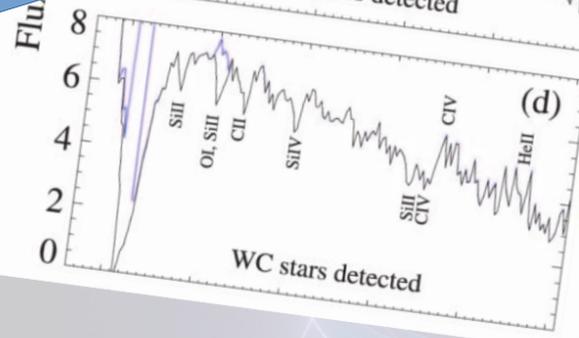
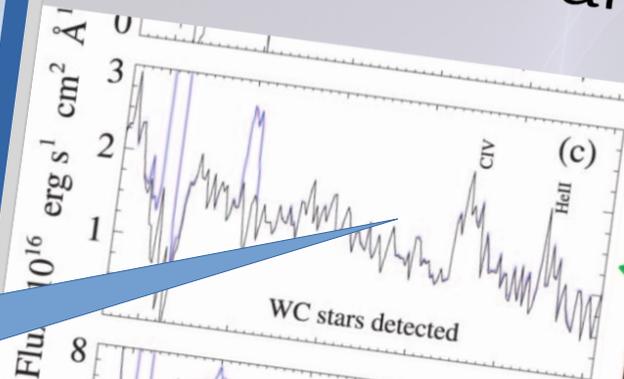
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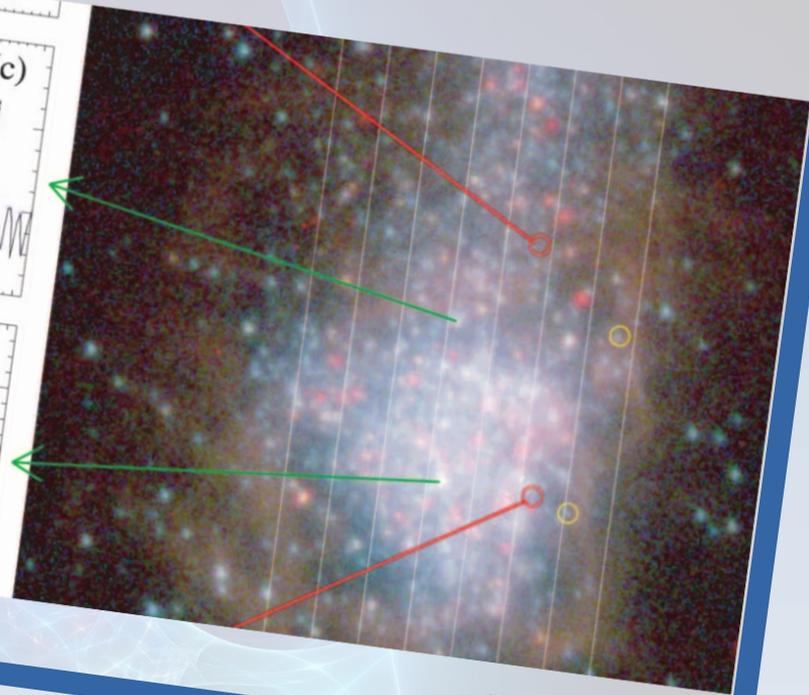
=contains
Wolf-Rayet stars

Hubble Space Telescope

There are *some* WCs...



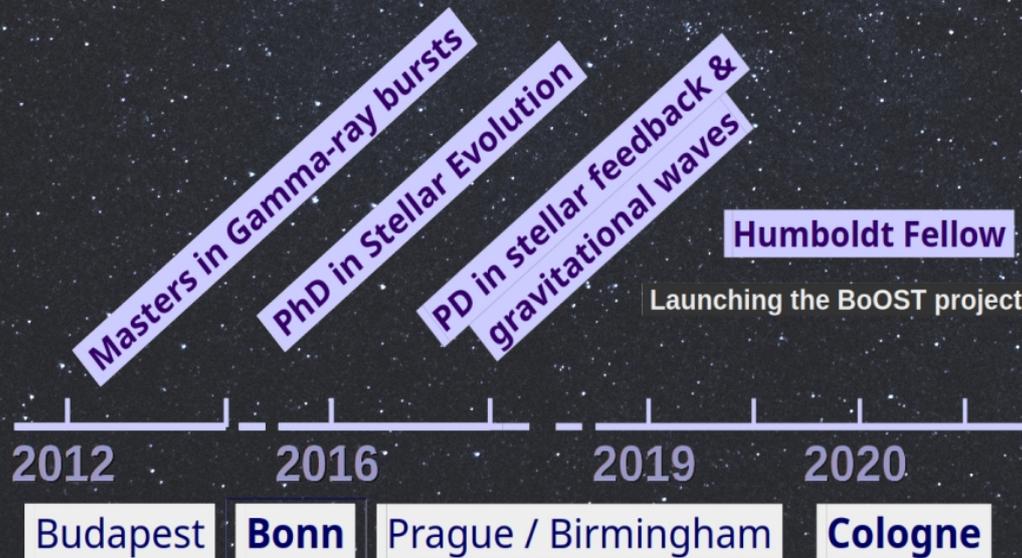
C IV (1550 Å)



Brown+02

Dr. Dorottya Szécsi,

Hey, I can use that! But only if I do a post-doc in...



Early career

Prague!



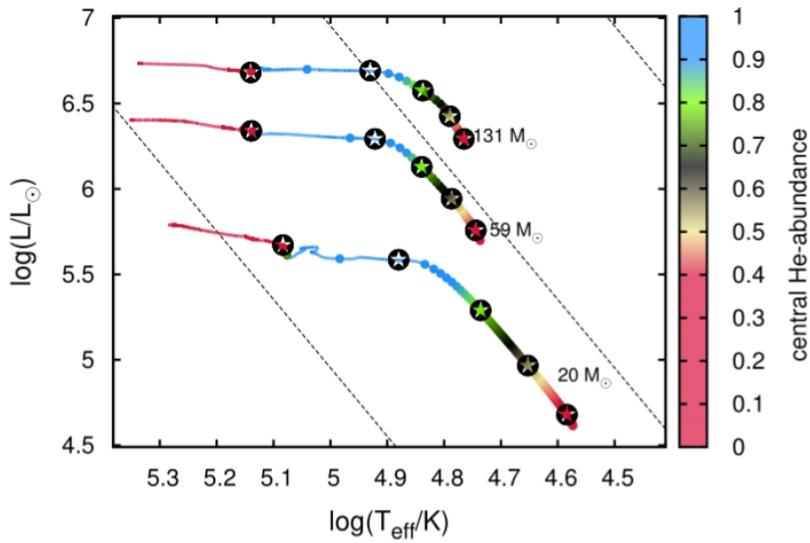
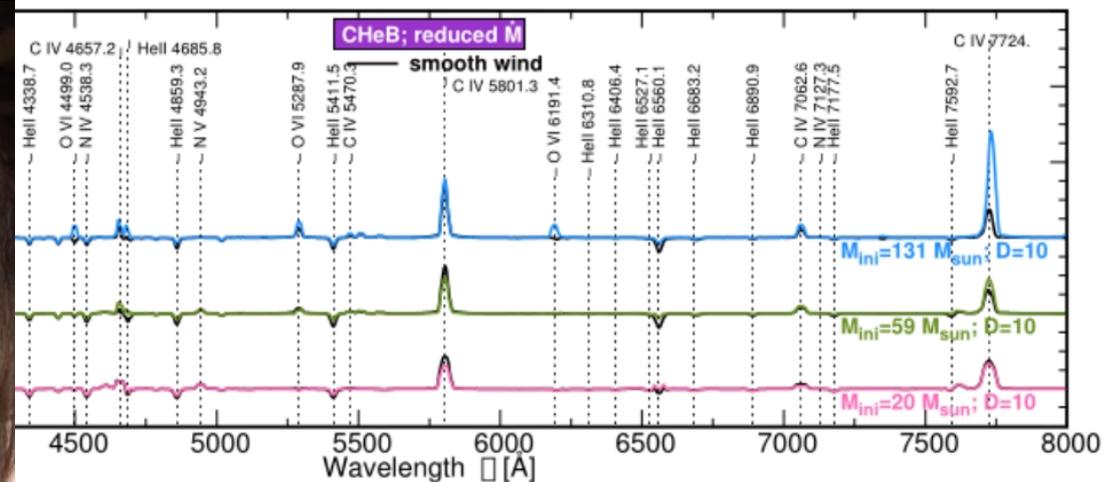
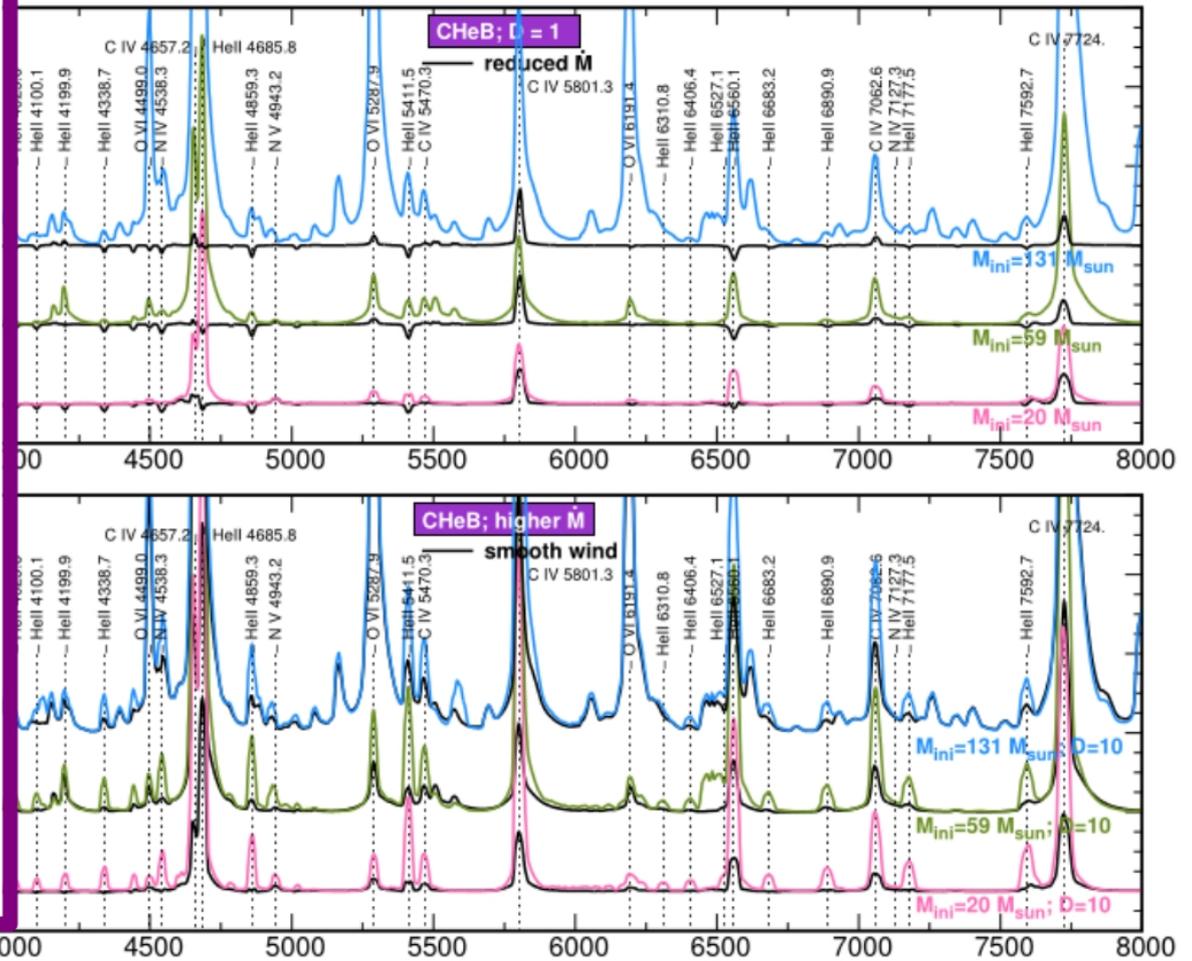


Fig. 1. HR diagram of our models (black symbols) and their corresponding evolutionary sequences. The sequences are taken from Paper I and Szécsi (2016). Initial masses are labeled, showing where the tracks start their evolution, proceeding toward the hot side of the diagram. Colors show the central helium 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

Brankica Kubátová
(& Jiří Kubát)



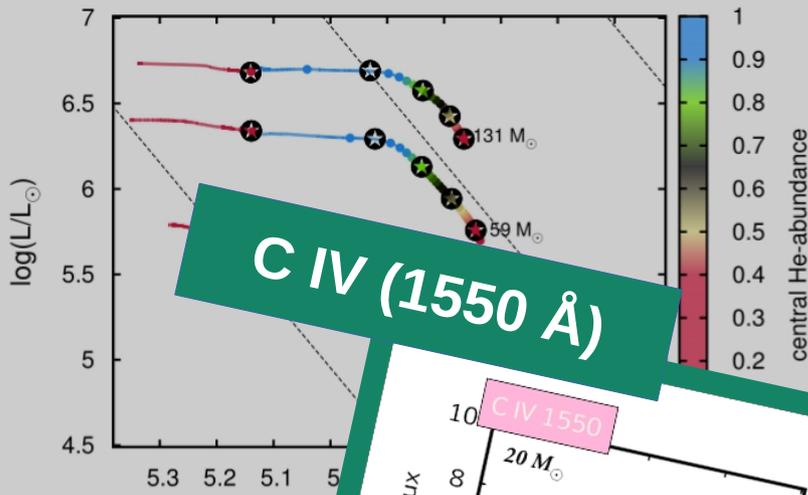


Fig. 1. HR diagram of our main evolutionary sequences (Szécsi (2016)). Initial masses and their evolution, proceeding from left to right, show the central helium mass fractions at 10^5 years of evolution. The models for which we compare the spectra correspond to central helium mass fractions of 0.28, 0.5, 0.75, and 1.0. The left corresponds to a central helium mass fraction of the CHeB phase.

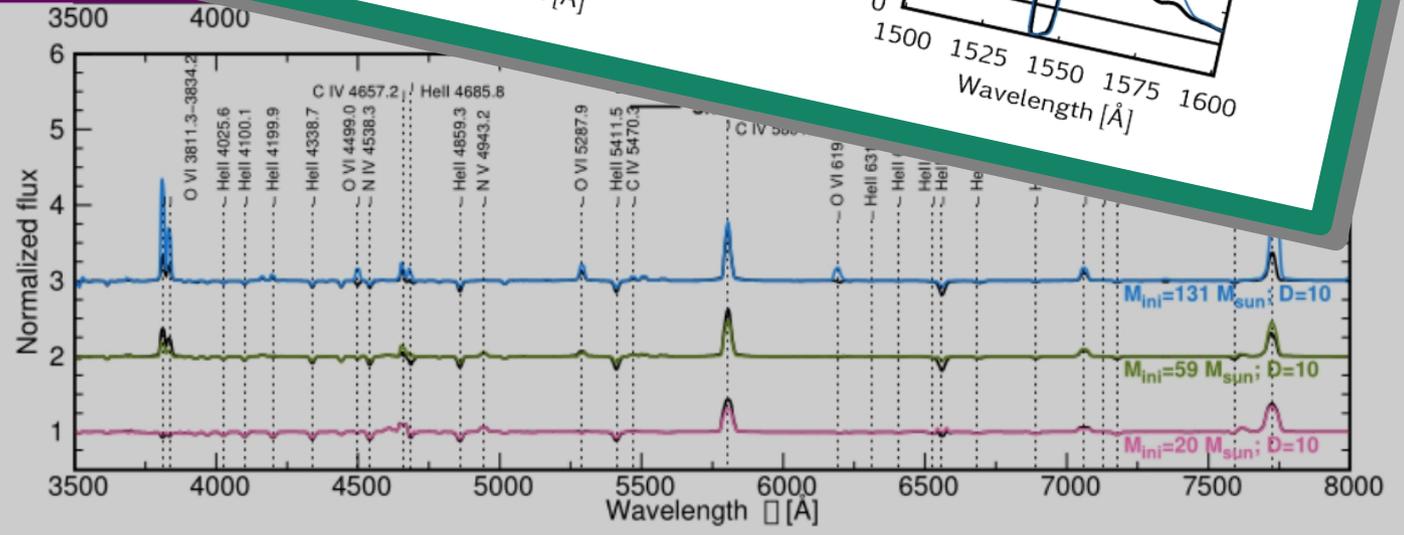
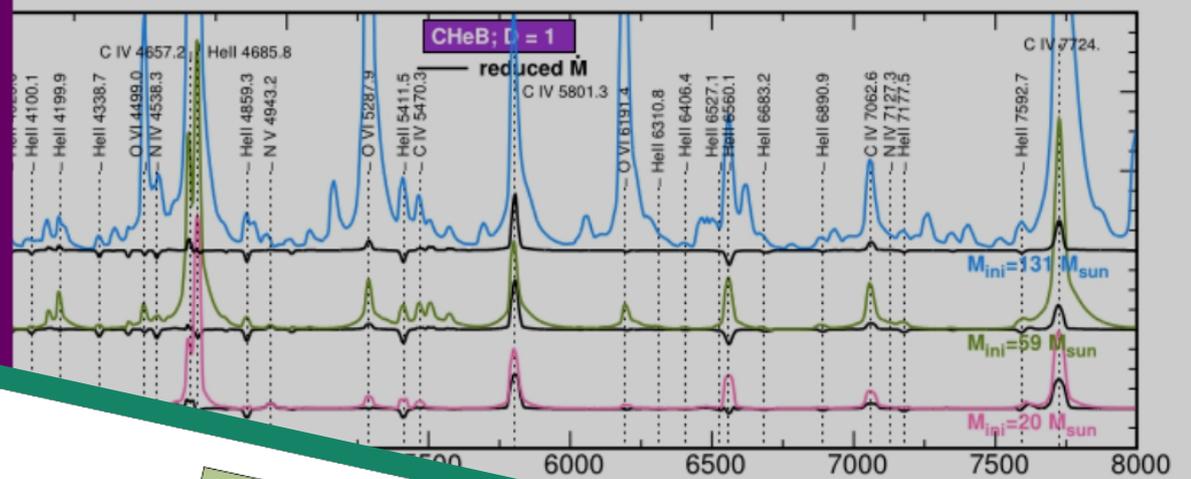
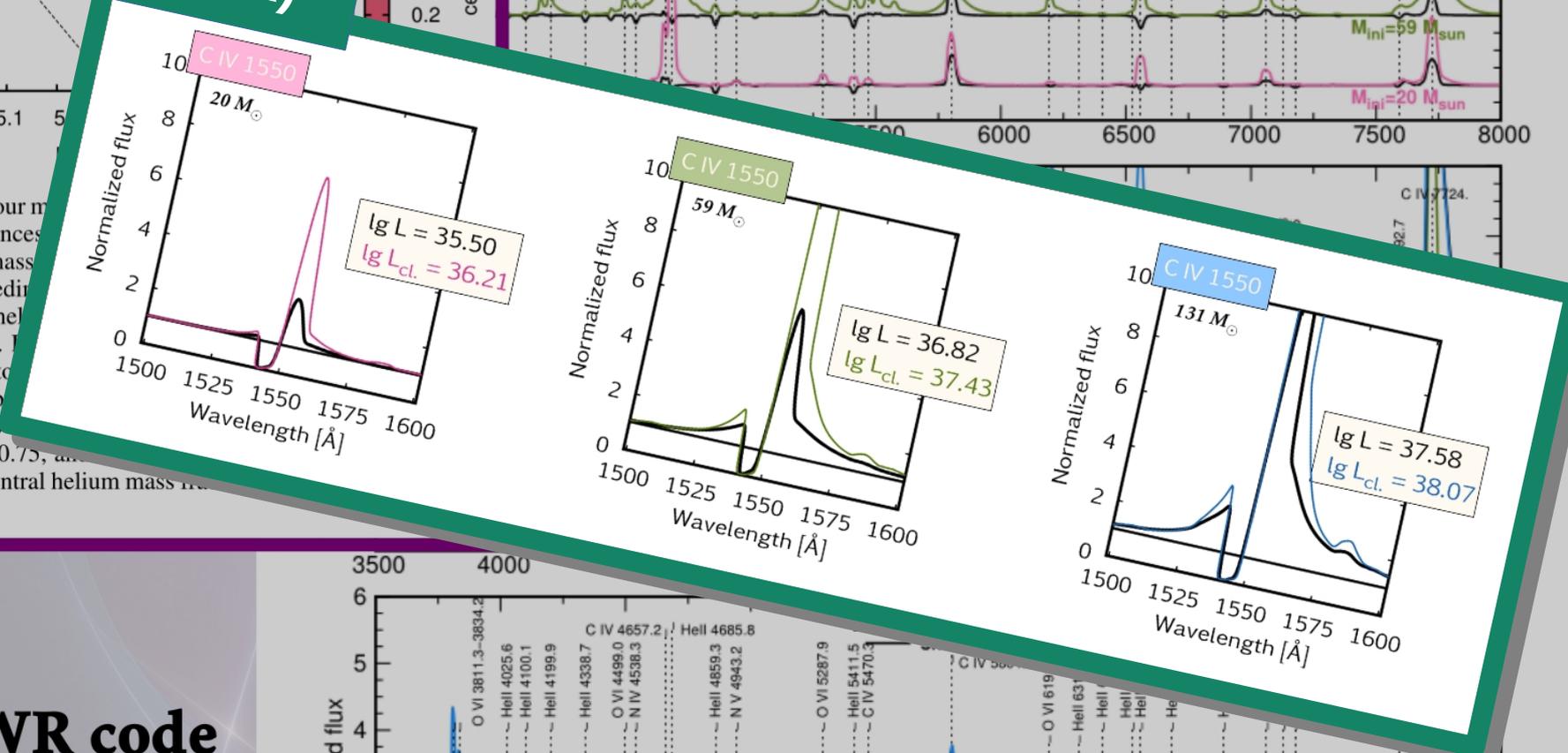


Fig. 4. Top panel: same as Fig. 3, but for the CHeB evolutionary phase with Y_c as given in Table 1. Middle and lowest panels: same as the top

PoWR code

Brankica Kubátová
& Jiří Kubát

+1 step

- “Population synthesis”

+1 step

- “Population synthesis”

*stellar models → population of stars

- Next post-doc in the UK
(Birmingham)

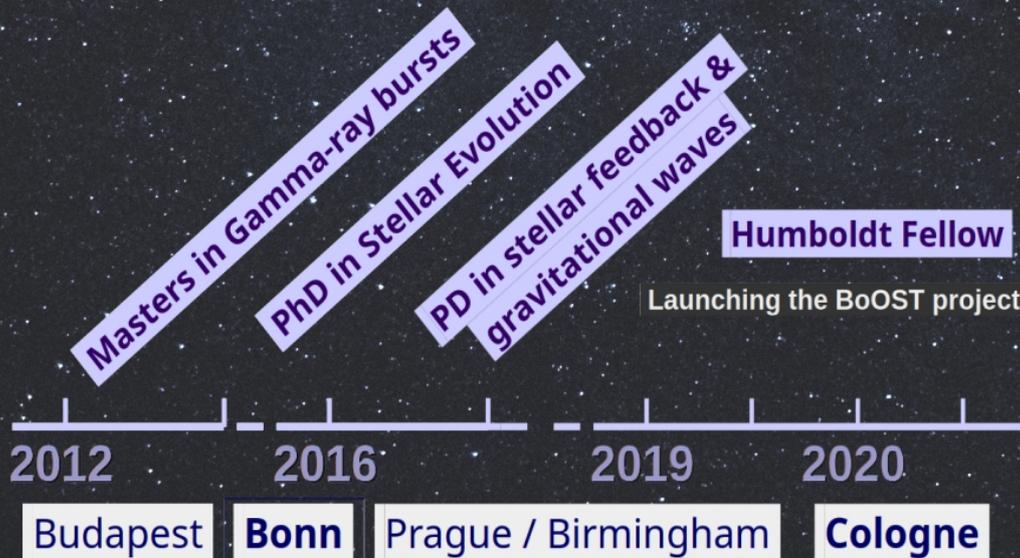


Dr. Dorottya Szécsi,

Humboldt Fellow

OMG it works!!

***2019**



Early career

3rd paper submitted in 2019...

Astronomy & Astrophysics manuscript no. output
April 25, 2019

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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.

Dorottya Szécsi¹, Brankica Kubátová², Andreas A.C. Sander^{3,4}, Jiří Kubát², and Carolina Kehrig⁵,

¹ I. Physikalisches Institut, Universität zu Köln, Zùlpicher-Strasse 77, D-50937 Cologne, Germany e-mail: dorottya.szecsi@gmail.com

² Astronomický ústav, Akademie věd České republiky, Fričova 298, 251 65 Ondřejov, Czech Republic e-mail: brankica.kubatova@asu.cas.cz

³ Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24/25, 14476, Potsdam, Germany

⁴ Armagh Observatory and Planetarium, College Hill, Armagh, BT61 9DG, Northern Ireland

⁵ Instituto de Astrofísica de Andalucía (IAA/CSIC), Glorieta de la Astronomía s/n Aptdo. 3004, E-18080 Granada, Spain

Received April 25, 2019; accepted ...

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*

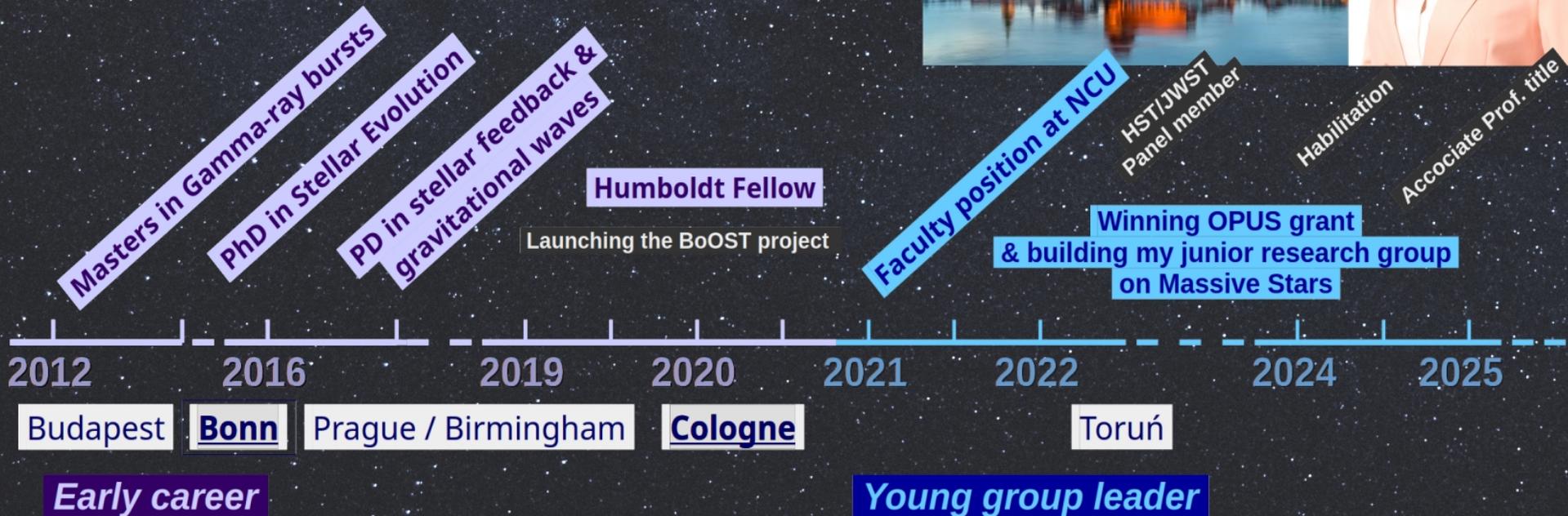




Dr. Dorottya Szécsi,

**Assistant Prof. &
OPUS group leader**

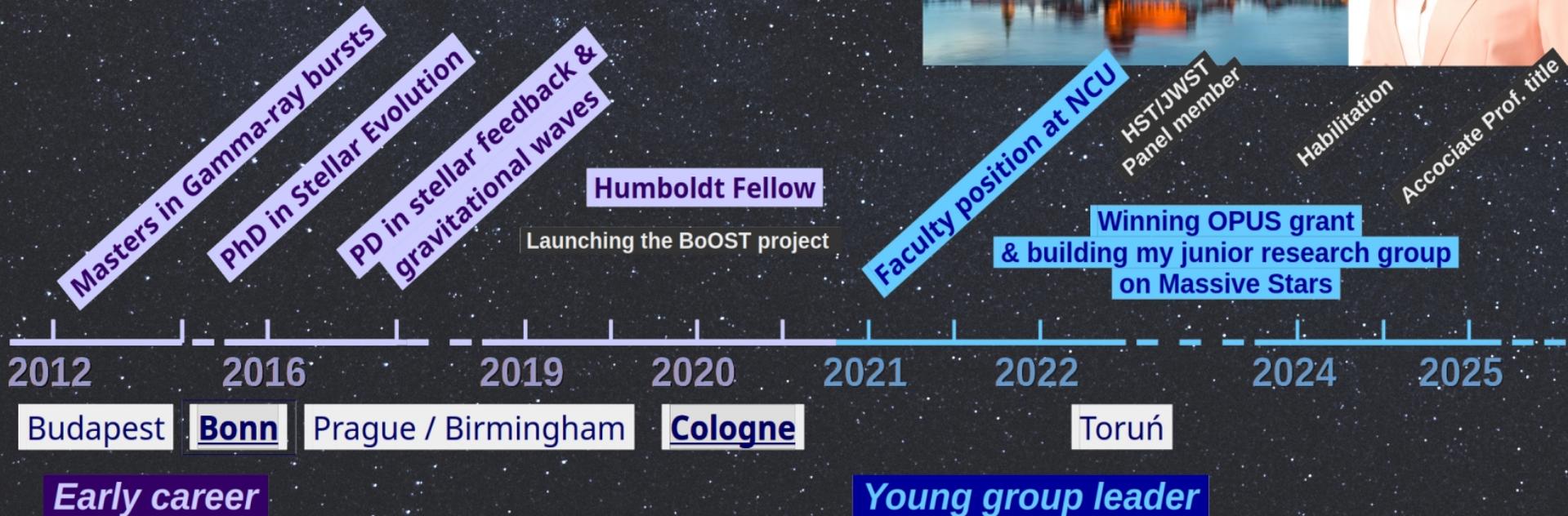
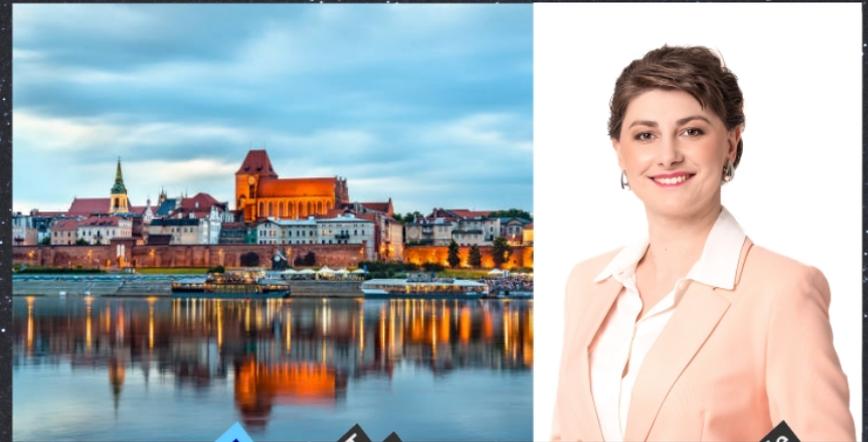
How did I get myself into this?



Dr. habil. Dorottya Szécsi, prof. UMK

What should I do?

Associate Prof. &
OPUS group leader

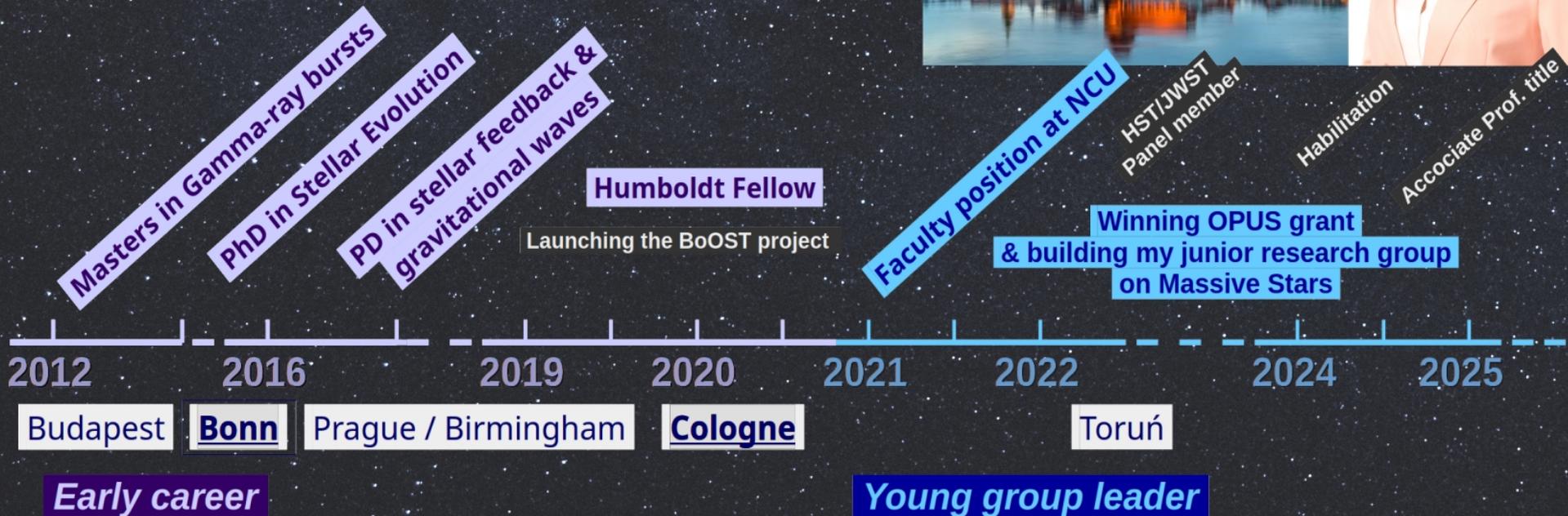
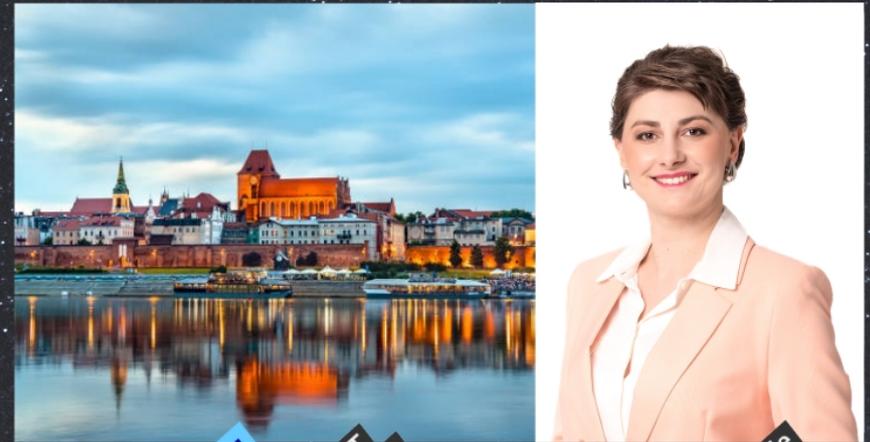


Dr. habil. Dorottya Szécsi, prof. UMK

What should I do?

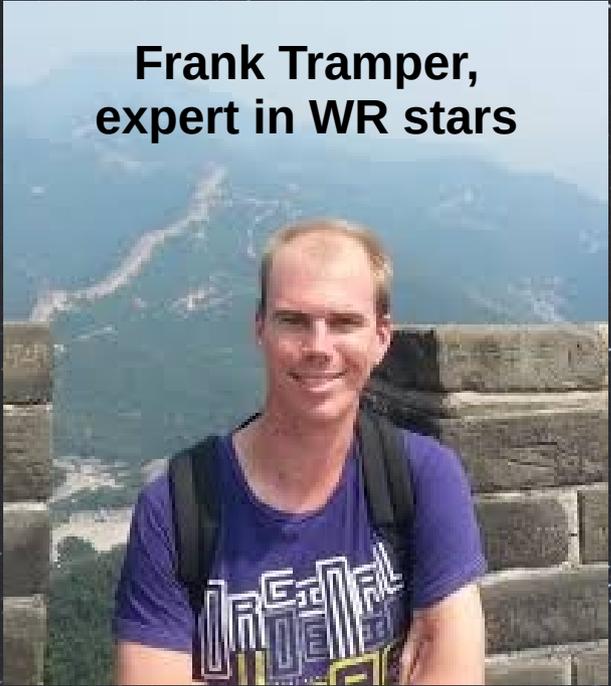


Associate Prof. &
OPUS group leader

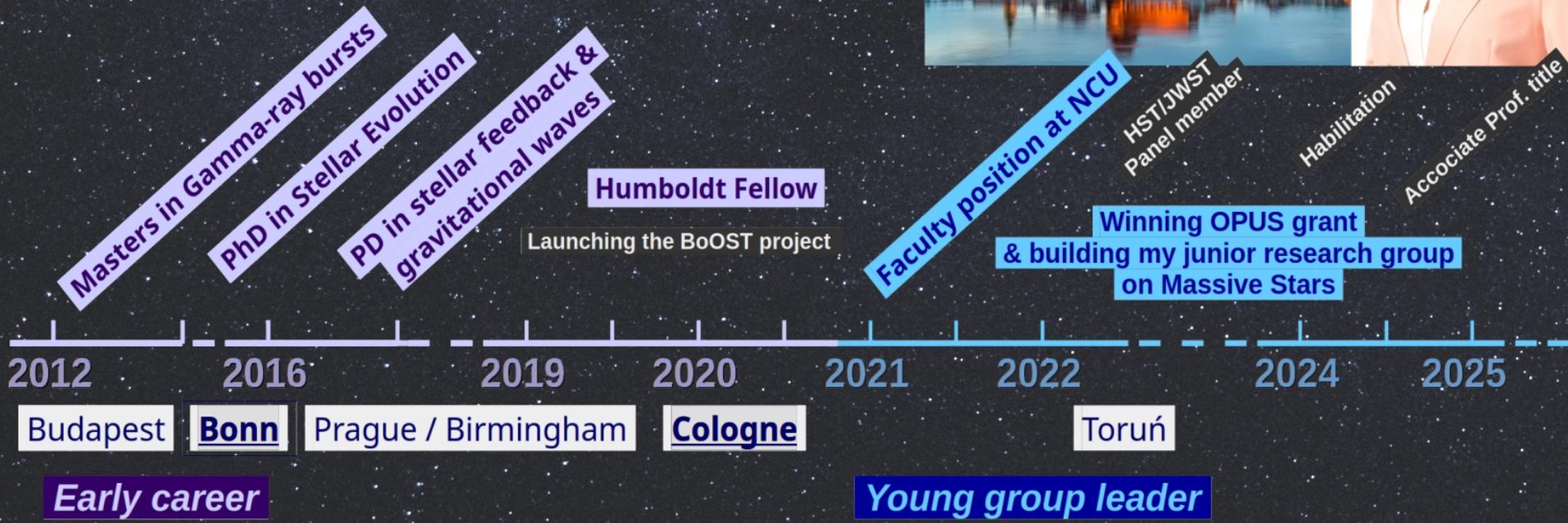
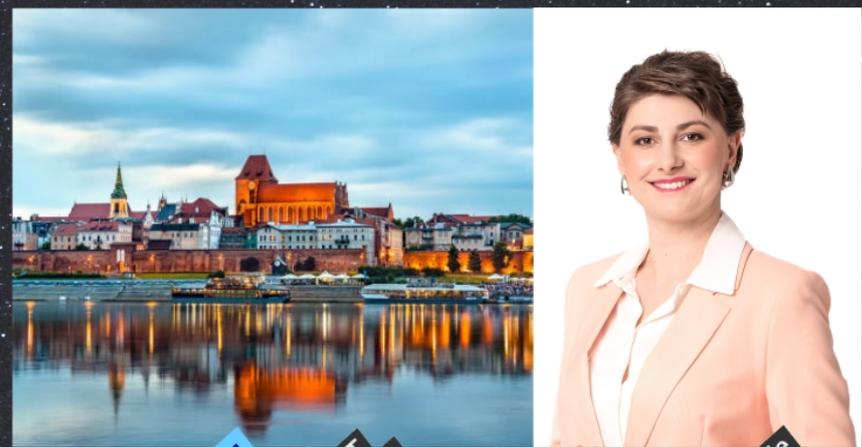


Dr. habil. Dorottya Szécsi, prof. UMK

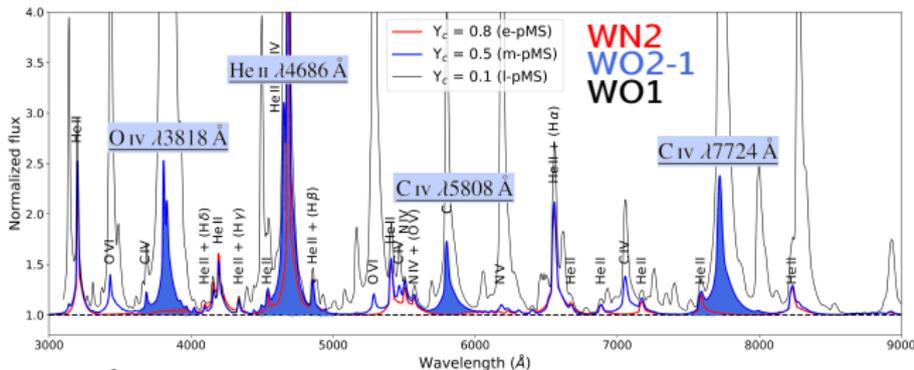
Frank Tramper,
expert in WR stars



Associate Prof. &
OPUS group leader

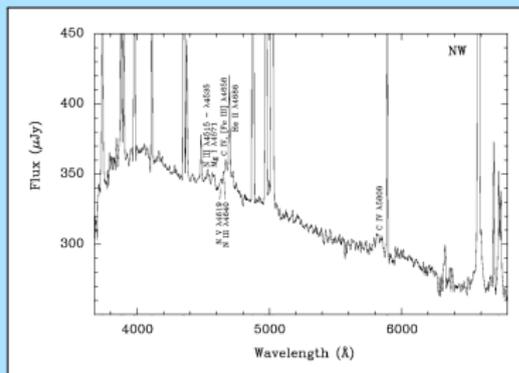


optical



3000 \AA

9000 \AA

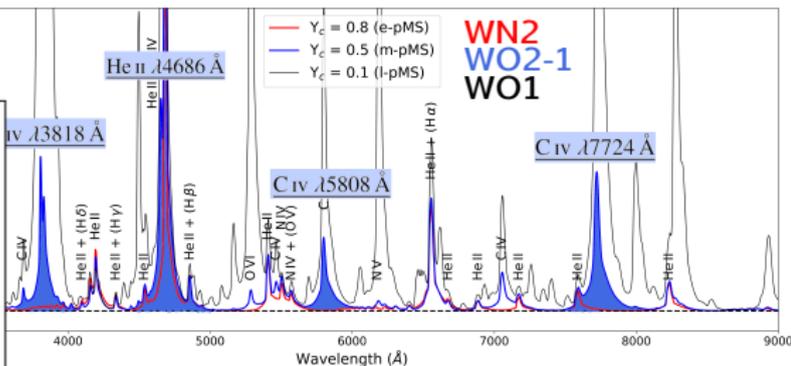
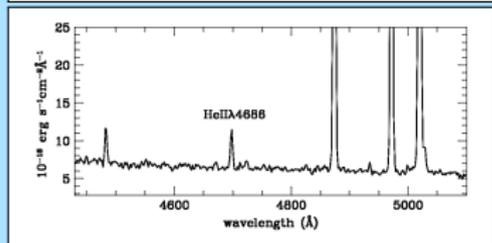
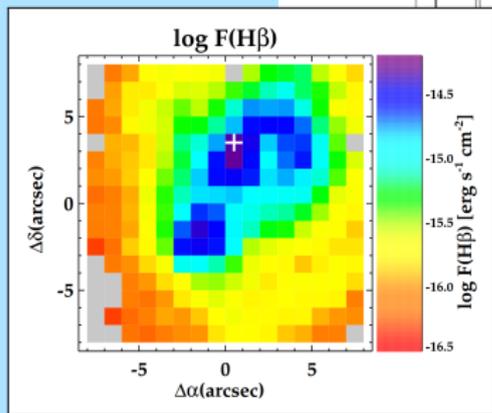


Izotov+97 3700 \AA –6800 \AA

name of dwarf galaxy:

I Zwicky 18

optical



9000 \AA

name of dwarf galaxy:

I Zwicky 18

Kehrig+15 4440 \AA –5200 \AA

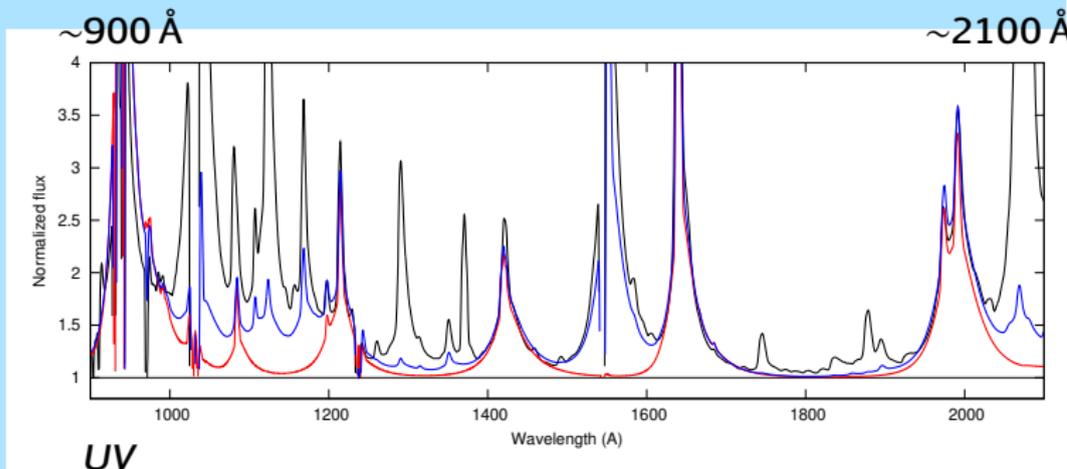
Brown+02 (HST STIS) 1160 Å–1710 Å



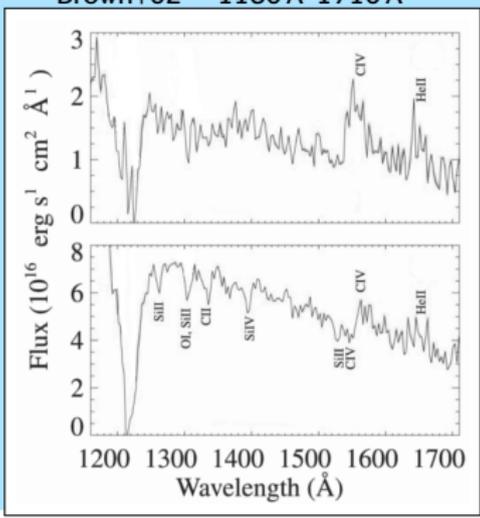
Lecavelier des Etangs+04 (FUSE) 910 Å–1185 Å



Heap+15/Berg+22 (HST COS) 1160 Å–1645 Å

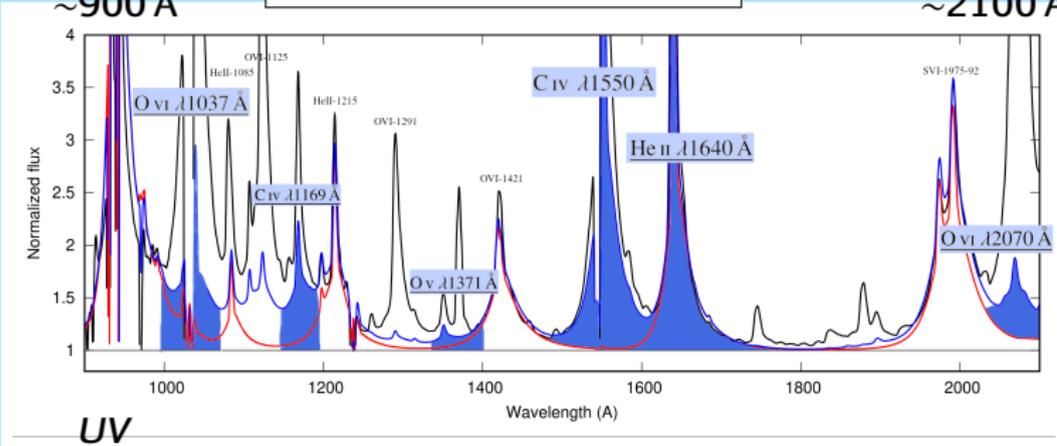


Brown+02 1160 Å-1710 Å

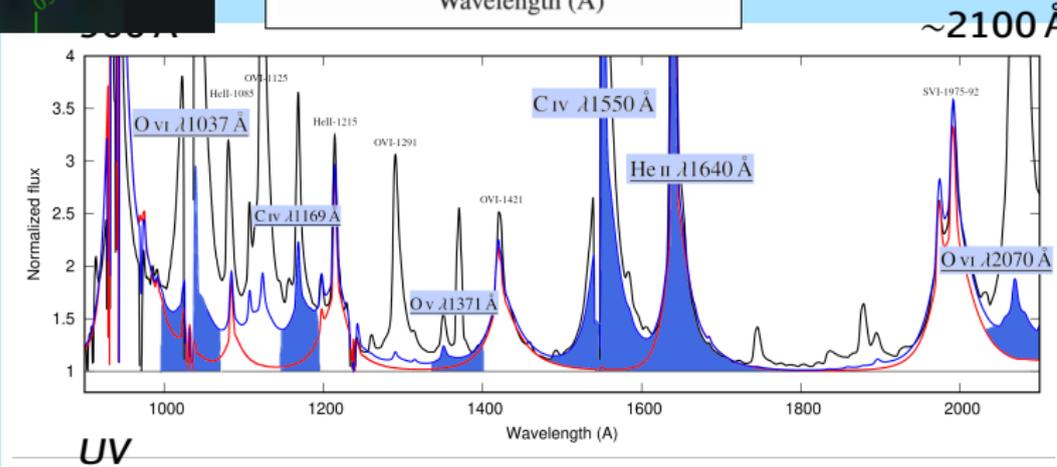
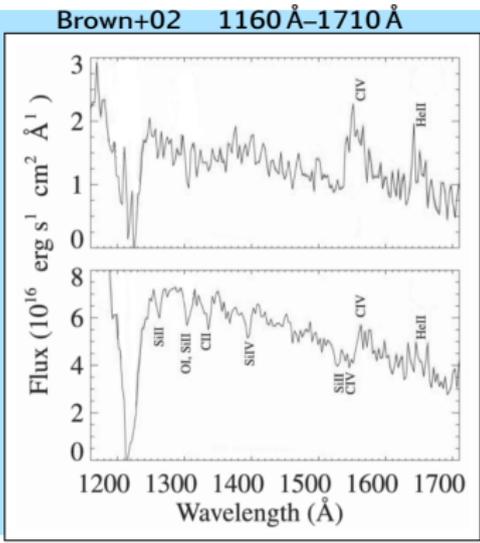
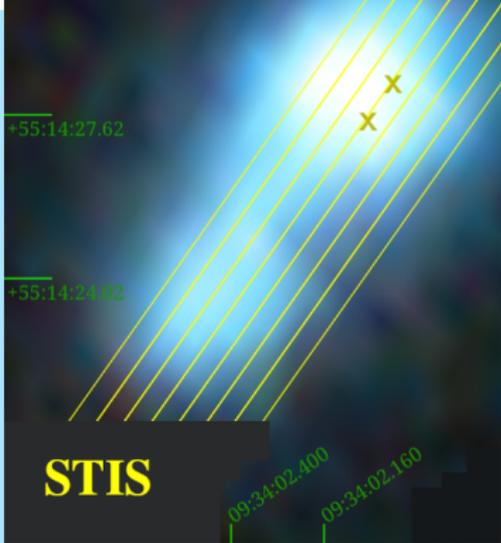


~900 Å

~2100 Å

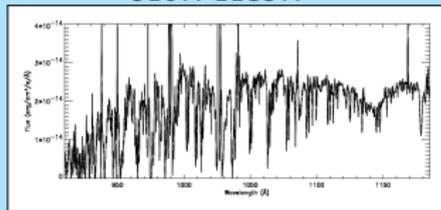


UV



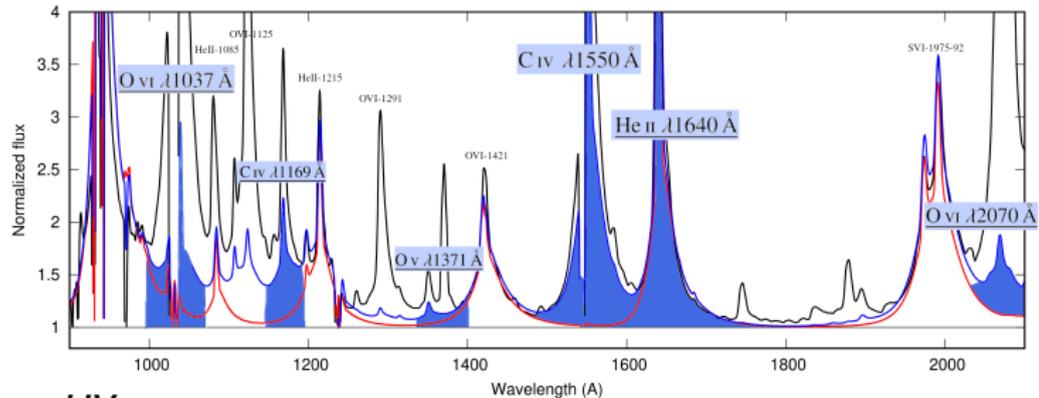
Lecavelier des Etangs+04

910 Å–1185 Å



~900 Å

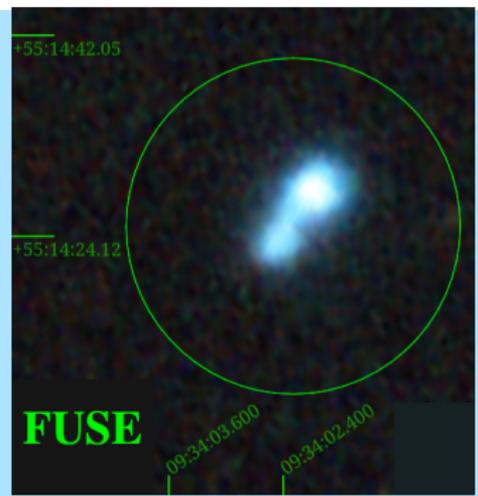
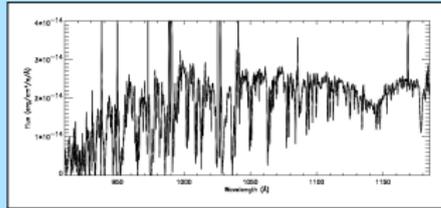
~2100 Å



UV

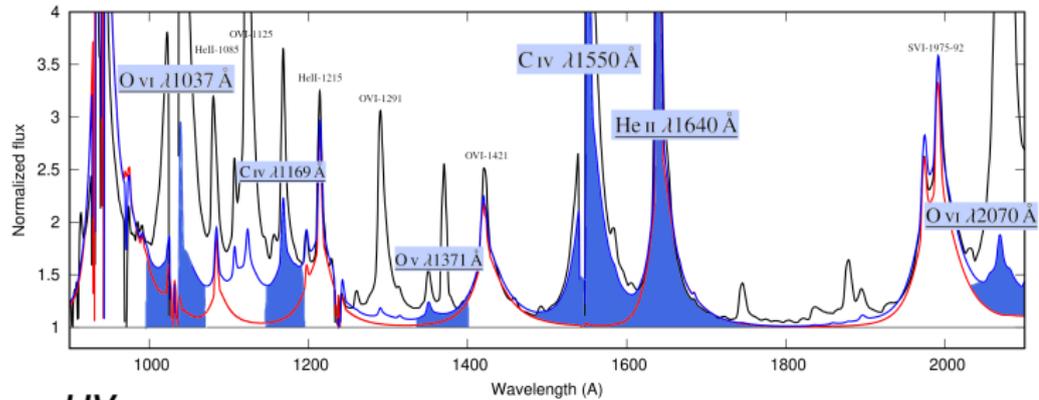
Lecavelier des Etangs+04

910 Å–1185 Å



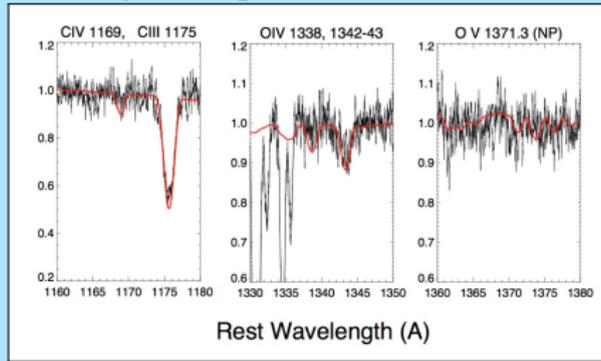
~900 Å

~2100 Å



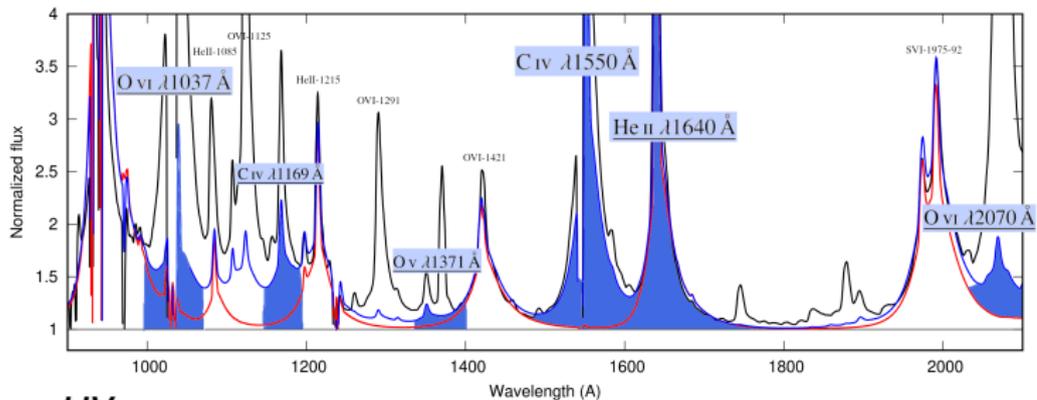
UV

Heap+15/Berg+22 1160 Å–1645 Å



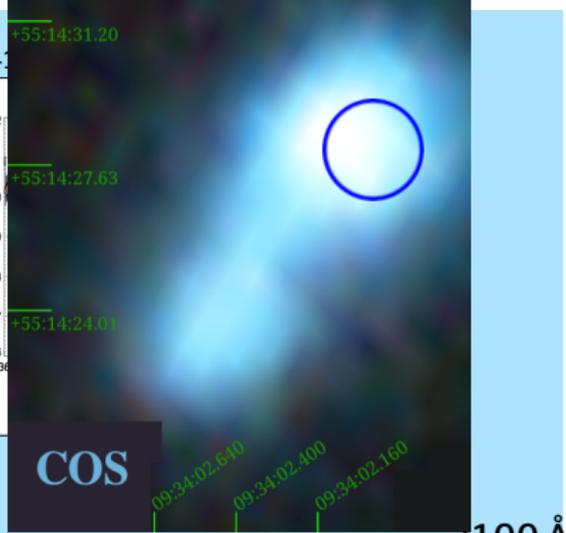
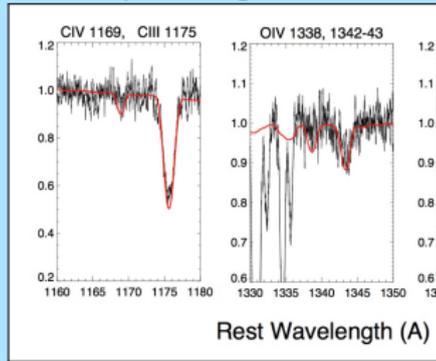
~900 Å

~2100 Å



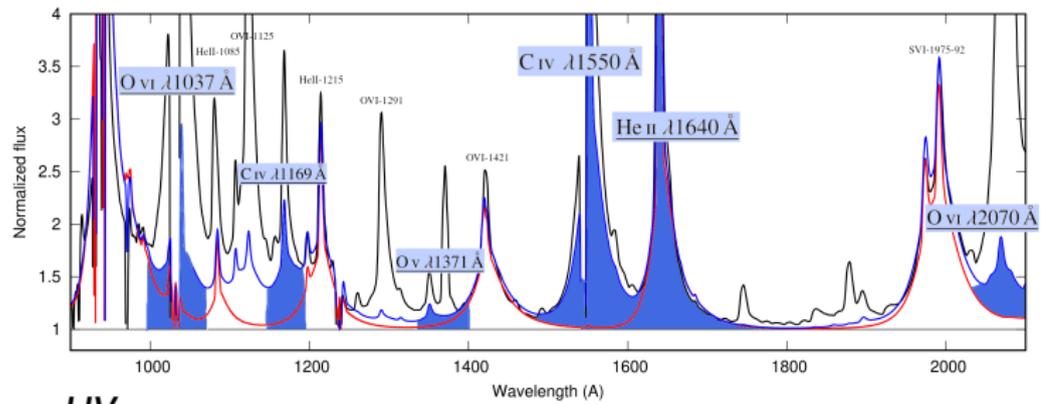
UV

Heap+15/Berg+22 1160 Å

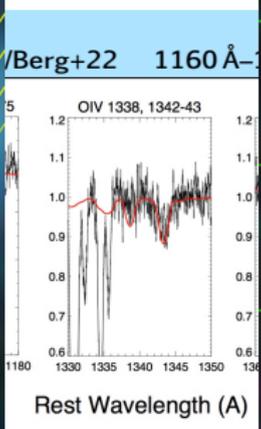
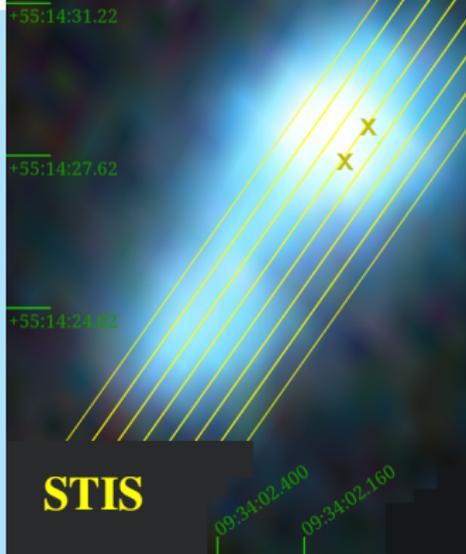


~900 Å

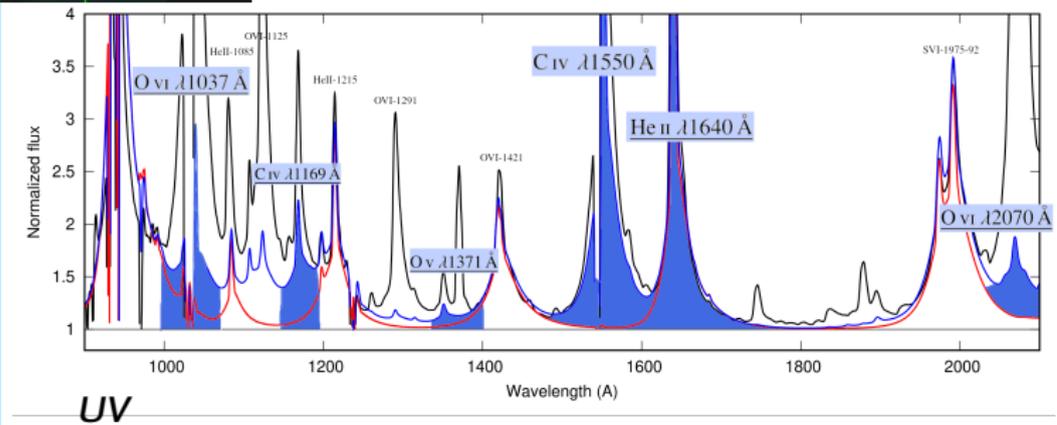
~2100 Å



UV



~2100 Å



Conclusions

Check out:
Szécsi+25 A&A
(in press)
arXiv:2506.21442

- ~~I was right all along :P~~
- Proving the existence of GW progenitors is **super hard** because ~~observations of sub-SMC galaxies are SHIT~~ observing sub-SMC galaxies is **super hard**.
- Did what's humanly possible with the available data
- AND IT'S CONSISTENT.
- Also: built a pipeline & established a methodology.

Future plans/ideas

- mining KECK archival data for WR stars... stay tuned!

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Thank you!