Spectroscopic study of massive, hot stars and their winds

Projects for future bachelor, master, or doctoral theses

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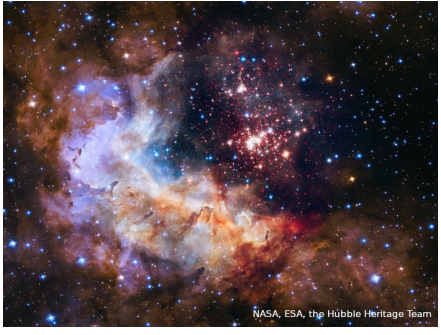
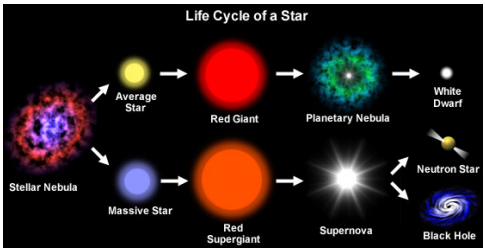
Astronomický ústav AV ČR



Motivation

- To understand the evolution and fate of massive stars in the Universe accurate mass-loss rates are crucial.
- Answers regarding the evolution of massive stars rely on theoretical and observational progress in our detailed understanding of stellar winds as a function of metallicity : $\dot{M} = \mathrm{f(Z)}$.
- Mass-loss recipes affect the nature and properties of the end products of stellar evolution, including SN types and compact remnants, and ultimately gravitational-wave progenitors (LIGO/Virgo: Abbott et al. 2016; Abbott et al. 2020).



XSHOOTU collaboration: ULLYSES & XSHOOTER

STELLAR PHYSICS DEPARTMENT

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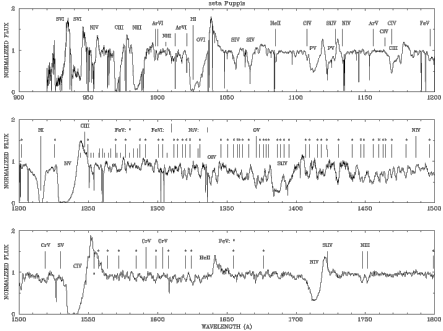
https://massivestars.org/xshootu/

- 14 Working Groups
- **WG4 - Wind Structure**
  Point of Contact:
  Brankica Kubátová

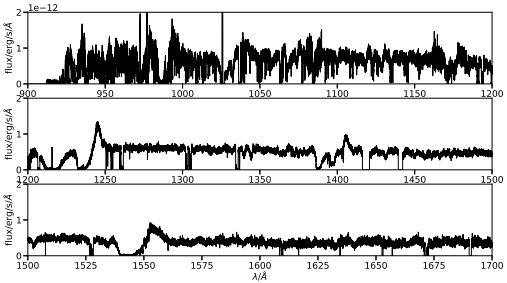
- **The NASA Hubble Space Telescope (HST)** - uniformly observed sample of the fundamental astrophysical parameter space for each mass regime - including spectral type, luminosity class, and metallicity for massive OB stars in **SMC** (Z=0.5 $\mathbf{Z}_\odot$), **LMC** (Z=0.2 $\mathbf{Z}_\odot$), **NGC 3109** (Z=0.1-0.2 $\mathbf{Z}_\odot$), and **Sextans A** (Z=0.1 $\mathbf{Z}_\odot$).
- Spectral types **O2-B1.5**, **supergiants B2-B9**, **11 WR stars** (4 close binary systems); about 240 stars.
- **HST observations** (FUV: 937-1792 Å+ archive data; NUV: 1607-3119 Å; OPT: 2900-5700 Å; NIR: 5240-10270 Å); **XSHOOTER observations** (UVB: 300-559.5 nm; OPT: 559.5-1024 nm; NIR:1024-2480 nm).
- **These observed data will be used in further bachelor, master, or PhD theses.**

Bachelor thesis topic 1

- **UV Spectroscopy of OB-type Stars**
  - Using archival data (IUE, FUSE, HST)
  - Understanding diagnostic lines for mass-loss rate, terminal velocity, and clumping properties determination



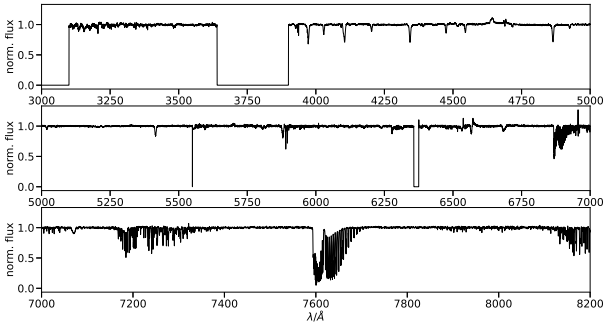
Merged spectrum of Copernicus and IUE UV high-resolution observations of the supergiant ζ Puppis (Pauldrach et al., 1994).



HST observation of the Sk-69 50.

Bachelor thesis topic 2

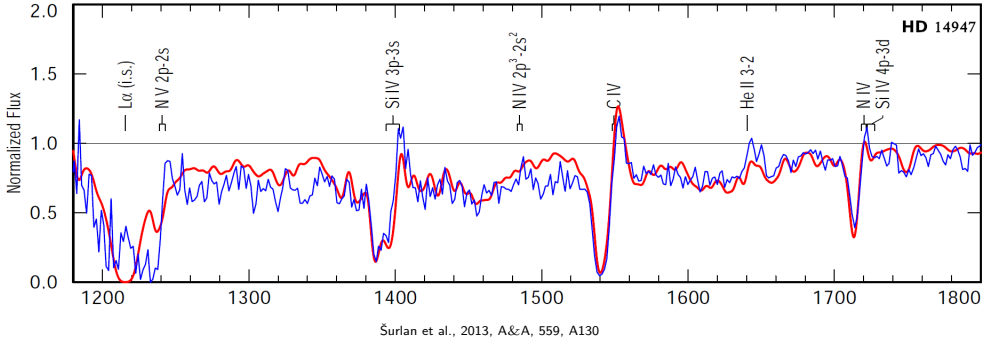
- **Optical (infrared) Spectroscopy of OB-type Stars**
  - Using archival data (HST, XShooter, ...)
  - Understanding diagnostic lines for stellar and wind properties determination



XSHOOTER observation of the Sk-66 171.

Master thesis topic

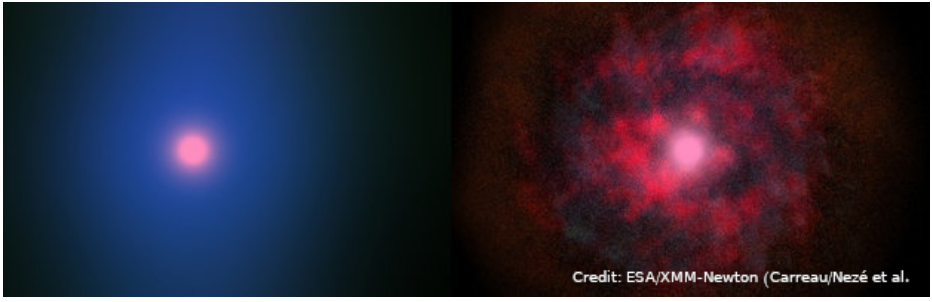
- **Spectral modelling of OB-type stars**
  - Analysis of only one chosen star
  - Using optical, UV, IR archival data
  - Using PoWR NLTE stellar atmosphere codes
  - Determination of stellar and wind parameters



Šurlan et al., 2013, A&A, 559, A130

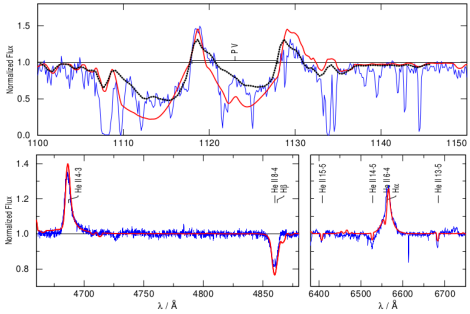
PhD theses topics

- **How wind properties change along spectral and luminosity classes at different metallicity?**
  - Wind properties
    - Mass-loss rate
    - Terminal velocity
    - Clumping properties



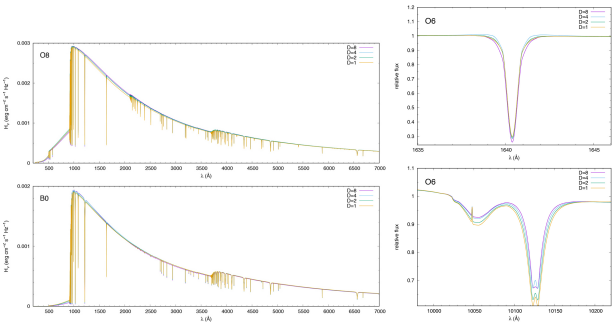
PhD theses topics

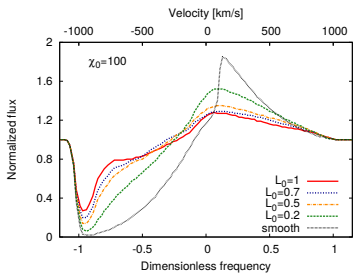
- **How wind properties change along spectral and luminosity classes at different metallicity?**
- **Empirical study - quantitative spectroscopy**
  - Analysis of larger sumple of stars using the newest HST and XSHOOTER observations
  - Using NLTE stellar atmosphere codes: PoWR, CMFGEN, FASTWIND, and/or 3D MCRT code
  - Calculation of synthetic spectra and their comparison with observations to determine stellar and wind parameters (e.g., Šurlan et al., 2013, A&A, 559, A130).



PhD theses topics

- **How wind properties change along spectral and luminosity classes at different metallicity?**
- **Theoretical study**
  - Contribution to the development of sophisticated radiative transfer and/or hydro-dynamic codes for stellar atmospheres and wind modelling (e.g., Šurlan et al., 2012, A&A, 541, A37; Kubát & Kubátová, 2021, A&A, 655, A35; Krtička, Kubát & Krtičková, 2022, A&A, 659, A117).
  - Outputs: spectral energy distribution, line profiles or wind structure (T, ρ, V).





Contacts

- For all questions and further discussions about possible bachelor, master, or PhD theses, please contact:

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  - **doc. RNDr. Jiří Kubát, CSc.**
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Completed PhD thesis: see **here**

Completed MSc. theses: see **here**
References: **J. Kubát** & **B. Kubátová**

- We will be happy to share our knowledge and experience with you and to help and to lead you to successfully finishing of your study.