NEW RESULTS AND THE IMPACT OF THE UV HST OBSERVATIONS ON OUR UNDERSTANDING OF A MASSIVE BINARY IN A METAL POOR GALAXY

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NUVA eMeeting 2021

Massive stars are important cosmic engines

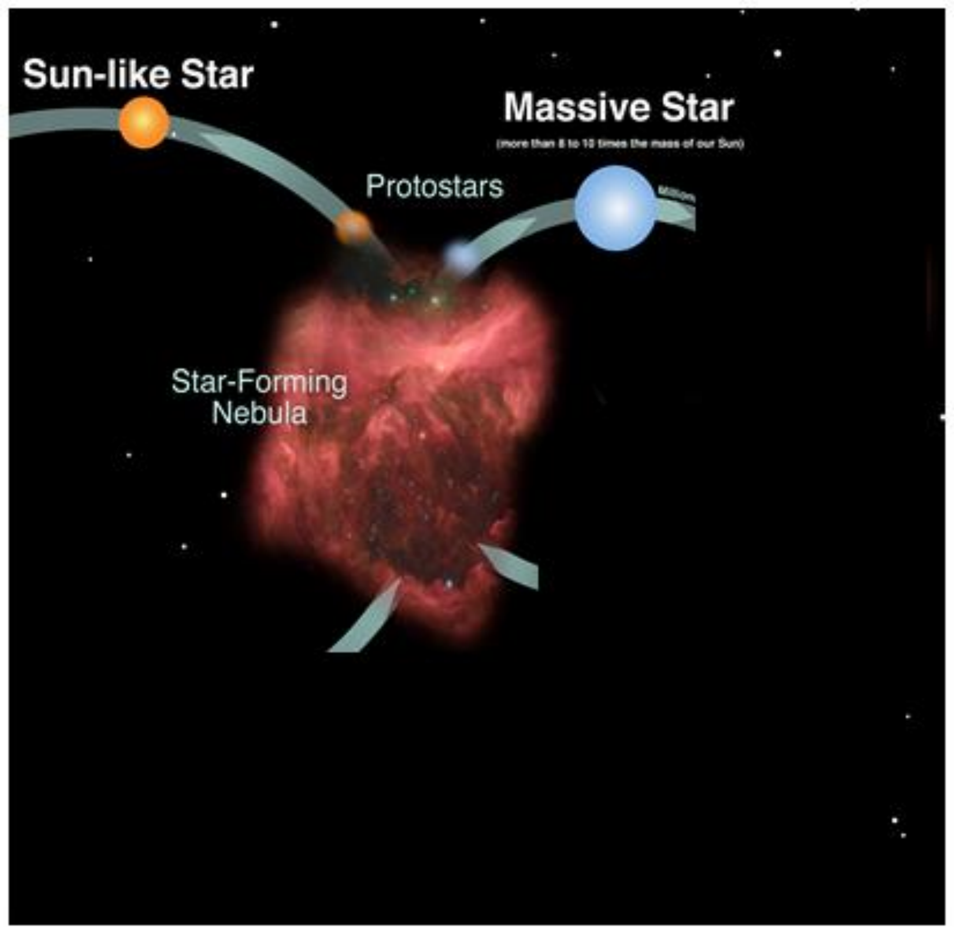


Image credit: NASA and Night Sky Network

- live only a few million years
  → alter ISM on a dynamic timescale
- spend >90% of live as hot stars (T > 20kK)
- hot star = strong UV flux
  → ionization of the surrounding, shaping ISM and impacting star formation
- lose several solar masses via stellar winds
  → enrich ISM with metals

→ UV yields information about wind
  → how much mass feed into ISM
  → how strong is ionizing flux

Massive stars are important cosmic engines

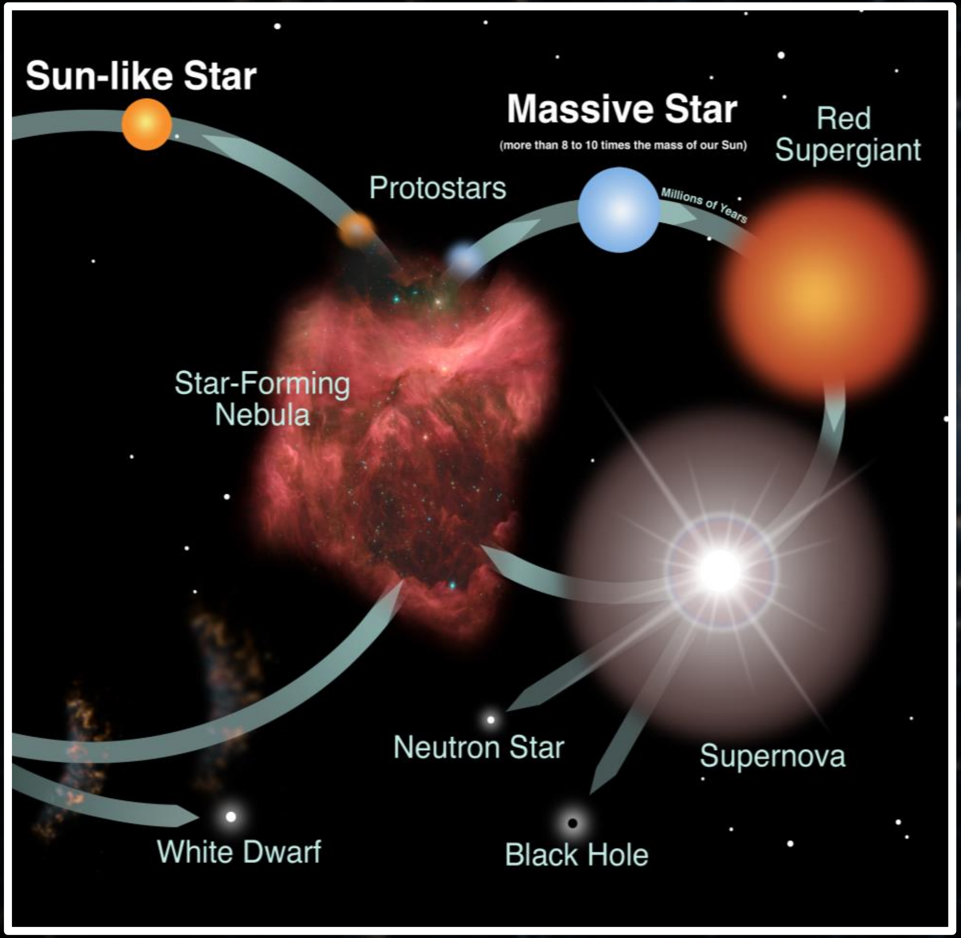
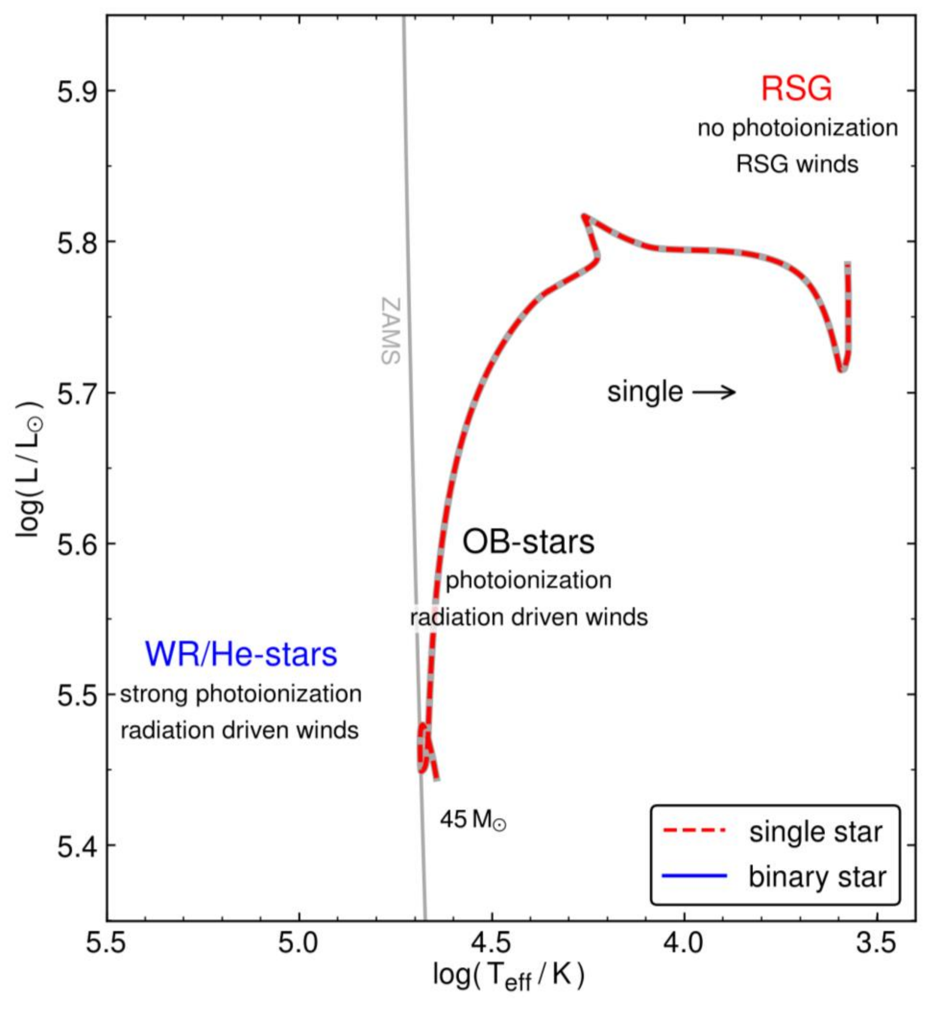


Image credit: NASA and Night Sky Network

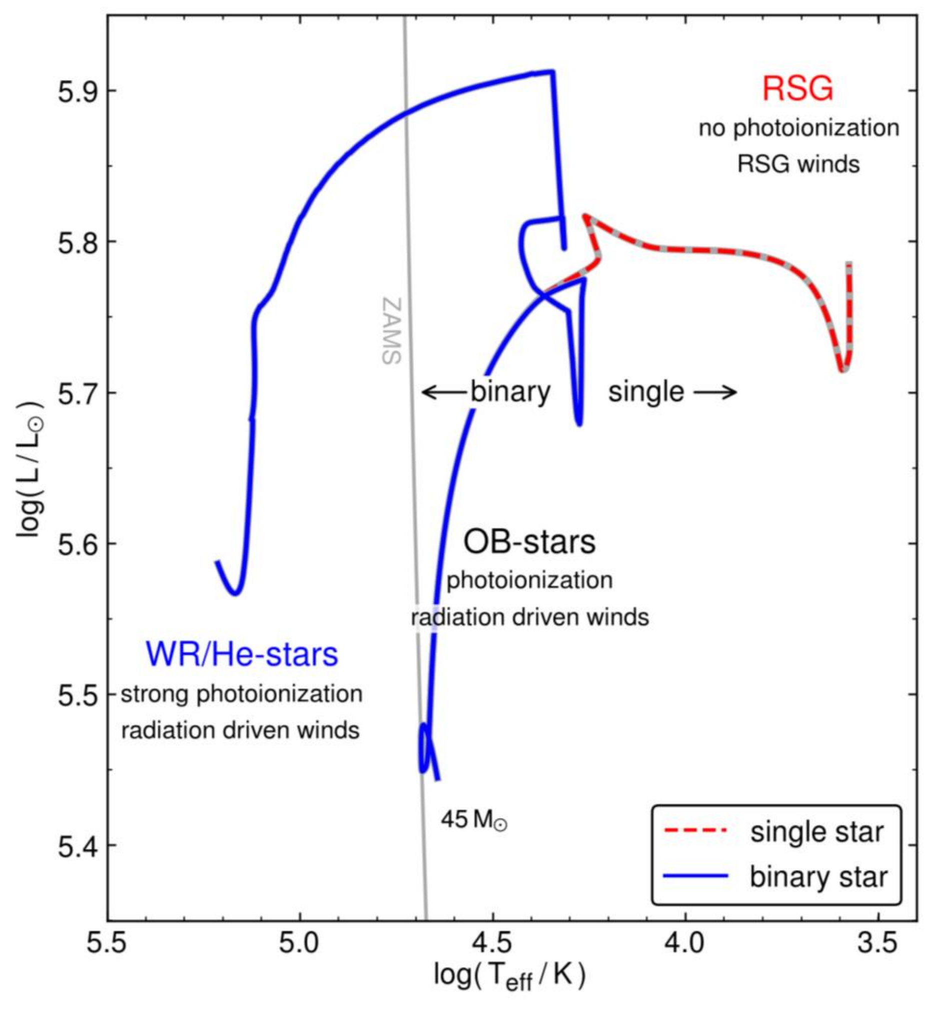
- stars evolve, explode as supernovae and enrich ISM with heavy elements
- evolution of a star is strongly influenced by mass loss
- progenitors of BH and NS (and currently detected gravitational wave events)
- stellar feedback, including supernovae, important for galactic evolution and structure of ISM

Single star evolution



- massive stars (OB stars) have line driven winds that partially remove H-rich envelope
- their winds are driven by UV radiation pressure on metal ions
  → wind strength depends on metallicity
  → main diagnostic lines in UV
- after H-burning, H-rich envelope expands and leads to efficient cooling
  → RSG phase
- RSG to cool for H ionizing flux

Binary evolution



- in binaries H-rich envelope is removed via mass-transfer
  → binary star has higher luminosity than a single star with similar mass (higher L / M ratio)

- higher L / M ratio = higher radiation pressure
  → higher L / M ratio = stronger wind (compared to single star with same L)

- star evolves into a WR/He-star which has a stronger wind and more ionizing flux than an OB star
  → different feedback than RSG
  → different fate:
    - explode as different type of supernova
    - form BH or NS with different mass
    - progenitors of BH-BH mergers

How to study the impact of binarity?

An ideal laboratory is …

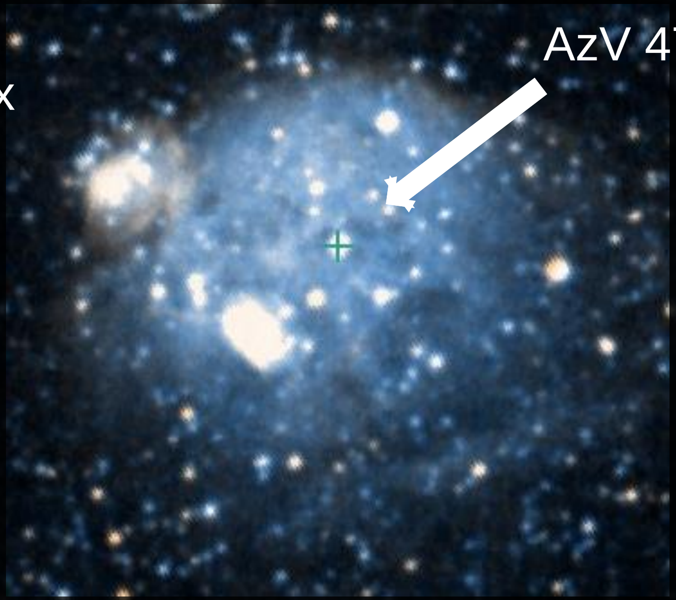
1. … a binary with early spectral type (= high mass?);
2. … known stellar masses;
3. … a post mass-transfer system (otherwise evolution same as for single star);
4. … in a low metallicity galaxy, to exclude that star has stripped of H-rich envelope via a stellar wind;
5. ... with accurate mass-loss rate to understand evolution and feedback mechanisms

→ high resolution UV spectrum

→ HST ideal for this task!

Our HST target: an early type eclipsing binary

- AzV 476, an eclipsing binary → Keplerian masses
- in SMC Wing (low metallicity of 1/7 $Z_\odot$)
- surrounded by large H II region → strong ionizing flux



DSS image (optical)

Our preliminary results:

- early spectral types: O4 IV-III:p + O9.5: Vn

  → suggests high masses (49 $M_\odot$ + 18 $M_\odot$)

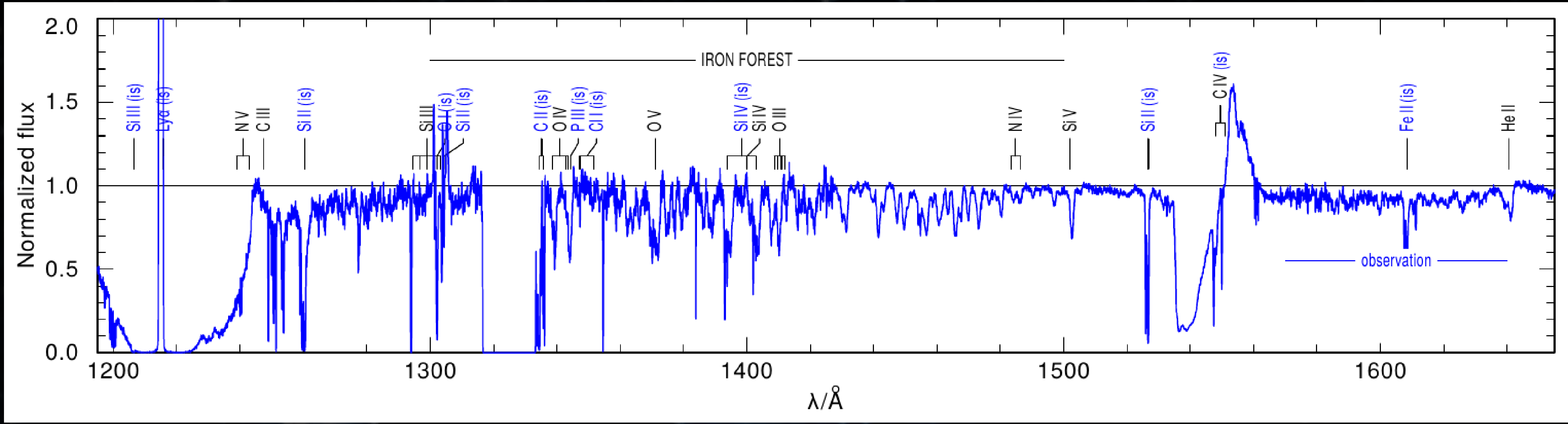
  → BUT: Keplerian masses: 20 $M_\odot$ + 18 $M_\odot$

  - log $L_1 / L_\odot$ = 5.65 and log $L_2 / L_\odot$ = 4.75
  - T_1 = 42 kK and T_2 = 32 kK
  - high L / M of primary → unusually strong wind

→ UV needed to unravel the present state and the future evolution of this system:

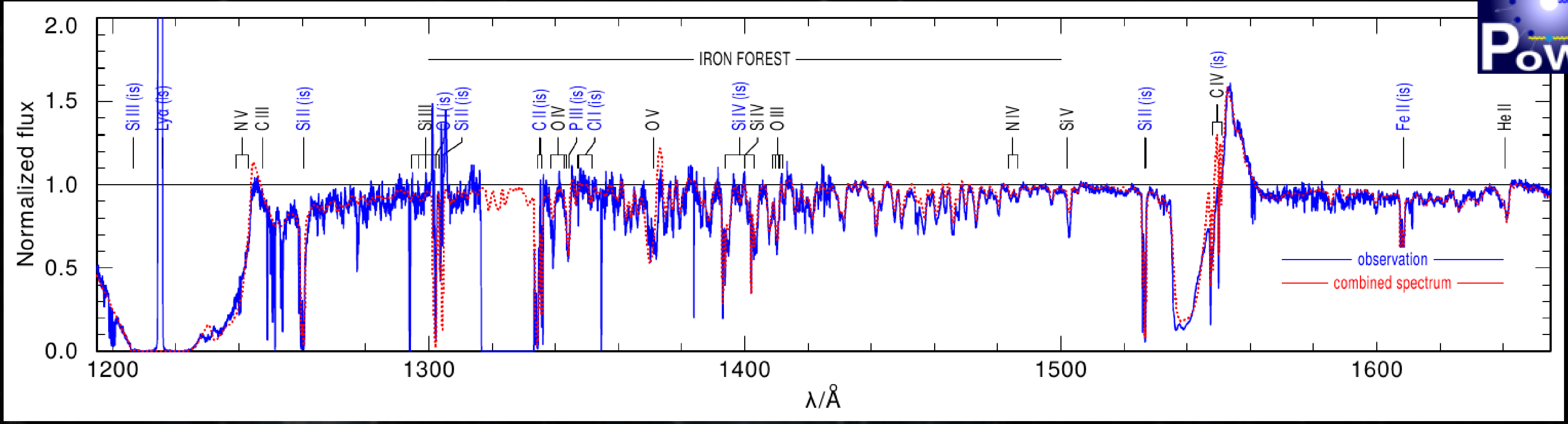
“What is the mass-loss rate and how does this impact the evolution?”

UV spectroscopy and massive stars



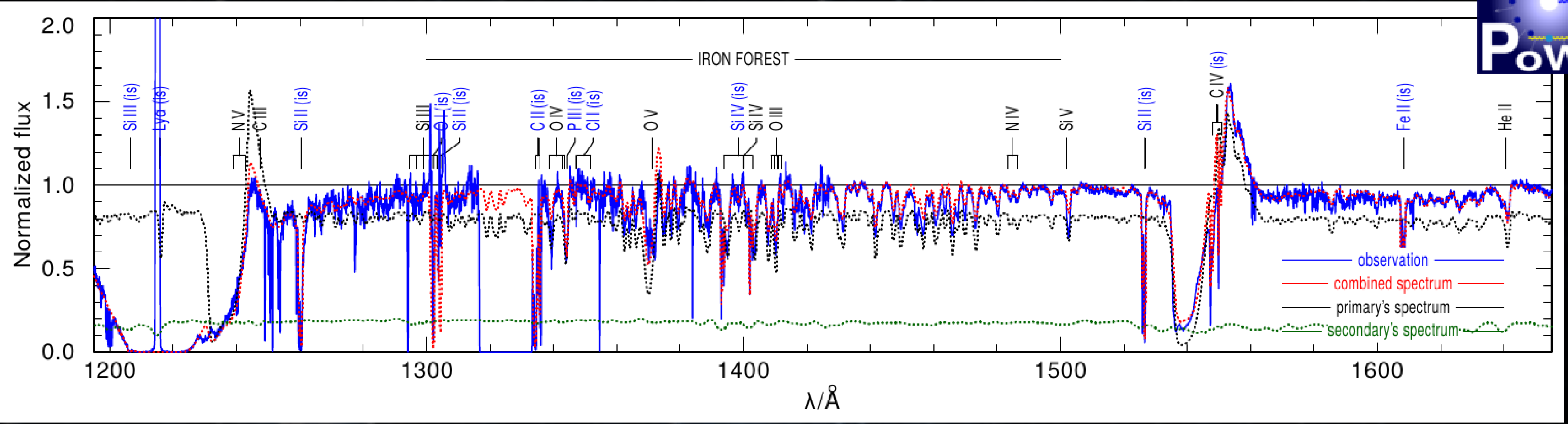
- HST STIS spectrum contains important information about the iron group element (iron forest), remember: radiation driven winds highly depend on metallicity!
- important wind diagnostic lines are in the UV, e.g. N V 1238, 1242, O V 1371, C IV 1548, 1550, He II 1640
- to study massive stars in the UV and unraveling their nature high resolution (R > 40 000) is needed to resolve all important lines
- UV spectra are essential to correctly understand massive star evolution

UV spectroscopy and massive stars



- analysis of stellar winds (flow of gas ejected from the upper atmosphere) requires non-LTE model atmosphere codes like PoWR
- code applicable for hot stars at any metallicity
- code returns detailed synthetic spectra
- comparison of synthetic and observational spectra in the UV and optical yields:
  - T, $\log L$, R, $\log g$, $\dot{M}$ and v_∞

UV spectroscopy and massive stars



- PoWR (detailed non-LTE stellar atmosphere) models reveal:
  - primary has unusual high mass-loss rate of log $\dot{M}_1 / (M_\odot / \mathrm{yr}) = -6.1$
  - SMC single stars with similar spectral class usually have log $\dot{M}_1 / (M_\odot / \mathrm{yr}) = -7.4$! (Ramachandran et al. 2019)

→ binary stripped stars can have winds that are 10 times stronger than usual!

→ high mass-loss strongly impacts evolution and feedback of ISM!

Conclusions

- UV spectroscopy is a powerful tool to unravel the mysteries of binary evolution
- Our example shows…
  - … a star in a post mass-transfer binary system has a wind that is 10 times stronger compared to a star evolved in isolation
  - … stars with similar mass can have totally different evolutionary stages
  - … the evolution and feedback of a star can change drastically in a binary system
  - **… that high resolution UV spectroscopy of massive stars is absolutely essential to understand massive star formation and their feedback to the ISM!**
- Further applications:
  - use UV spectral appearance as an additional constraint to find post mass-transfer binaries
  - understand impact of binarity on feedback processes