Stellar Winds of Hot Stars - Diagnostics from UV spectra

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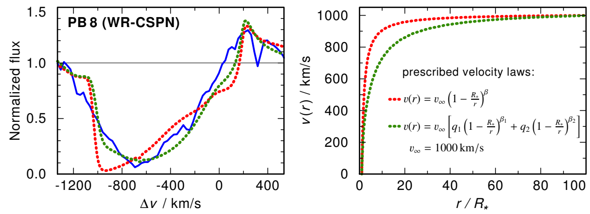
- Non-degenerated stars with strong UV flux drive winds → $\dot{M}$
- Winds drive stellar evolution and influence ISM (e.g. PNe)
- Therefore: need to know accurate mass-loss rates $\dot{M}$
- Wind parameters can be inferred from UV lines with help of models for stellar winds, including full non-LTE radiative transfer in expanding atmospheres

→ *employ sophisticated stellar atmosphere models, e.g. PoWR (Potsdam Wolf-Rayet model atmospheres)*

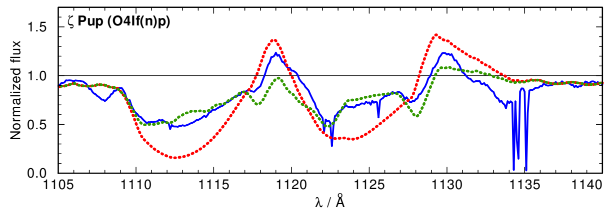
Measuring wind velocity $v(r)$



- P V resonance line $^2P^o_{1/2}$ - $^2S_{1/2}$ 1128 Å: FUSE observation vs. two models with different $v(r)$, 2β-law fits UV observation better than standard β-law
- Hydrodynamically self-consistent models (work in progress) yield $v(r)$ and $\dot{M}$ instead of prescribing them

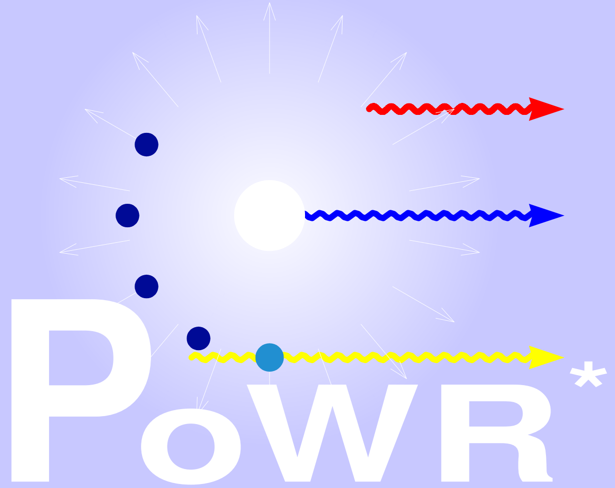
[1]

Determining $\dot{M}$ and clumping



- P V resonance doublet: COPERNICUS observation cannot be reproduced by a model with a typical $\log(\dot{M}/M_\odot/yr)=-5.6$ and micro clumping only
- Therefore: $\dot{M}$ is 10x lower, or keep $\dot{M}$ and take optically thick clumps (porosity) into account

[2]



Input

Stellar & wind parameters
- $T_{\rm eff}$, L, M
- $\dot{M}$, $v(r)$
- abundances X_i

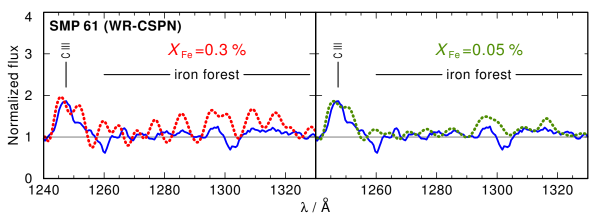
Atomic data
- levels, lines, etc.

Output

- radiation field
- ionization stratification
- emergent spectrum
→ comparison with observation to obtain stellar parameters

* Potsdam Wolf-Rayet model atmosphere code

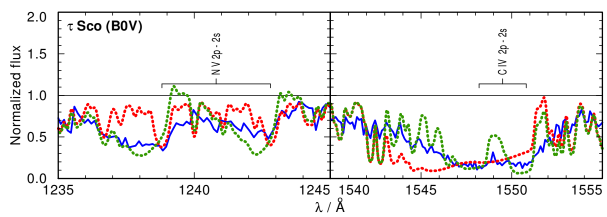
Chemical abundances - e.g. iron



- "Iron forest" in the UV formed by millions of lines from iron group elements (Sc - Ni)
- Strong UV flux absorbed by iron lines in UV drives wind
- STIS observation vs. models with $X_{\rm Fe,\,LMC}$ and $\frac{1}{6}X_{\rm Fe,\,LMC}$
→ iron depletion, due to s-process in former AGB star?

[3]

Superionization by X-rays



- IUE observation vs. a model with $\log(L_X/L_{\rm bol})=-6.4$, and for comparison a model without X-rays
- C IV is destroyed by X-rays, while N V is created
→ UV resonance lines sensitive to X-rays and therefore help to identify X-ray sources embeded in the wind

[4]

References:

[1] Todt H., Peña M., Hamann W.-R., Gräfener G.: 2010, Astron. Astrophys. 515, 83
[2] Oskinova L. M., Hamann W.-R., Feldmeier A.: 2007, Astron. Astrophys., 476, 1331-1340
[3] Stasinska G., Gräfener G., Peña M., Hamann W.-R., Koesterke L., Szczerba R.: 2004, Astron. Astrophys., 413, 32
[4] L.M. Oskinova, H. Todt, R. Ignace, J.C. Brown, J.P. Cassinelli, W.-R. Hamann: 2011, MNRAS 416, 1456