THE NEARBY, PRIMITIVE GALAXY, I ZW 18

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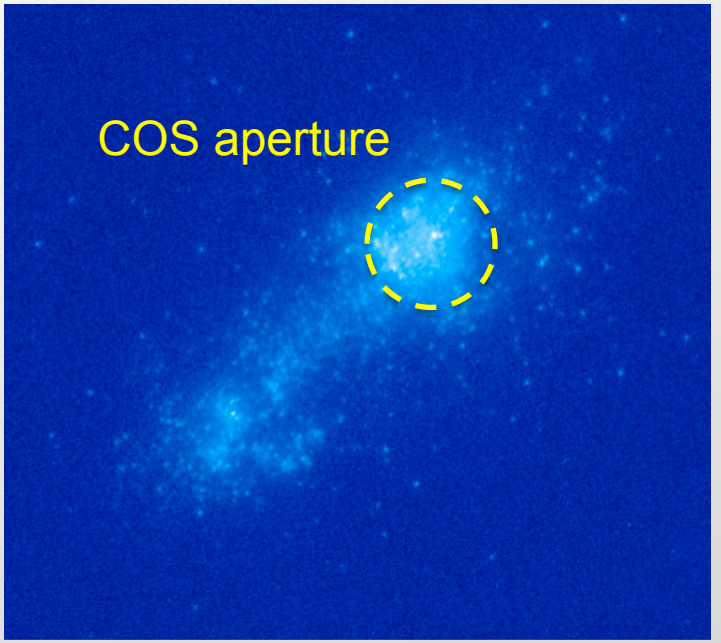


STIS Far-UV Image of I Zw 18
(Browm et al. 2002)

* in anticipation

Outline of Talk

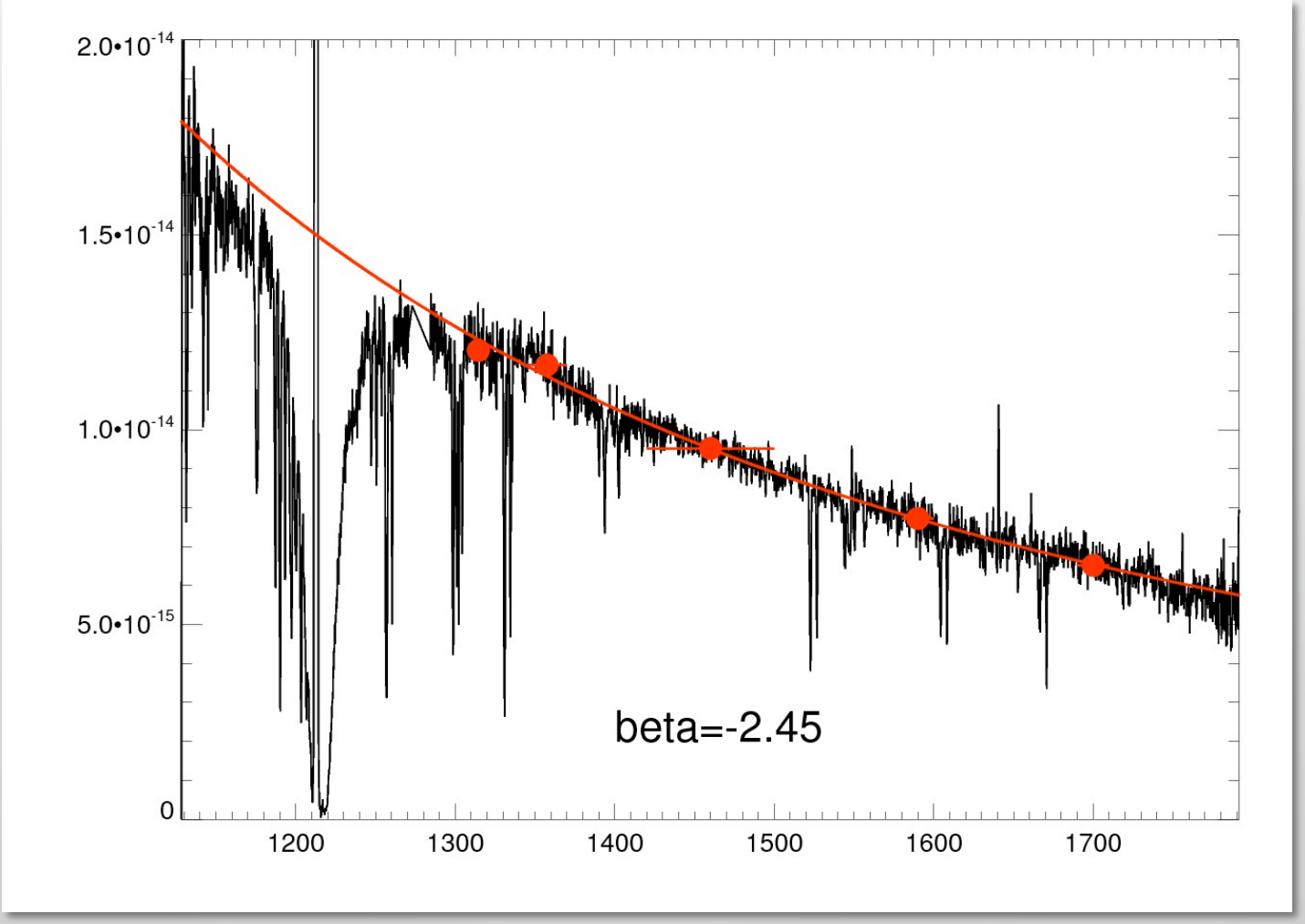
- Why I Zw 18 is useful for understanding high-redshift galaxies
- Observed properties of I Zw 18 stars, H II and H I regions derived from COS far-UV spectrum
- Implications for Evolutionary Processes in I Zw 18
  - Structural & dynamic evolution
  - Metal enrichment
  - Star-formation history

Comparison of I Zw 18 and z=7-8 Galaxies Found by WFC3

Property	I Zw 18	z=7-8 Galaxies
Stellar Mass ($M_\odot$)	2:x10^6	10^8 - 10^9
HI Gas Mass ($M_\odot$)	2.6x10^7	
Dynamical mass ($M_\odot$)	2.6x10^8	
SFR ($M_\odot$/yr)	0.1	10-100
Age of young stars (Myr) Age of older stars (Myr)	15 ≤500? ≥1000?	 <200
Metallicity ($Z/Z_\odot$)	< 0.03	< 0.05
Dust	low	low

I Zw 18 is a primitive galaxy
- Its baryonic mass (stars+ gas) is very low
- It has barely started to convert its gas into stars
- Its metallicity is very low: [O/H]=-1.45 in the HII region

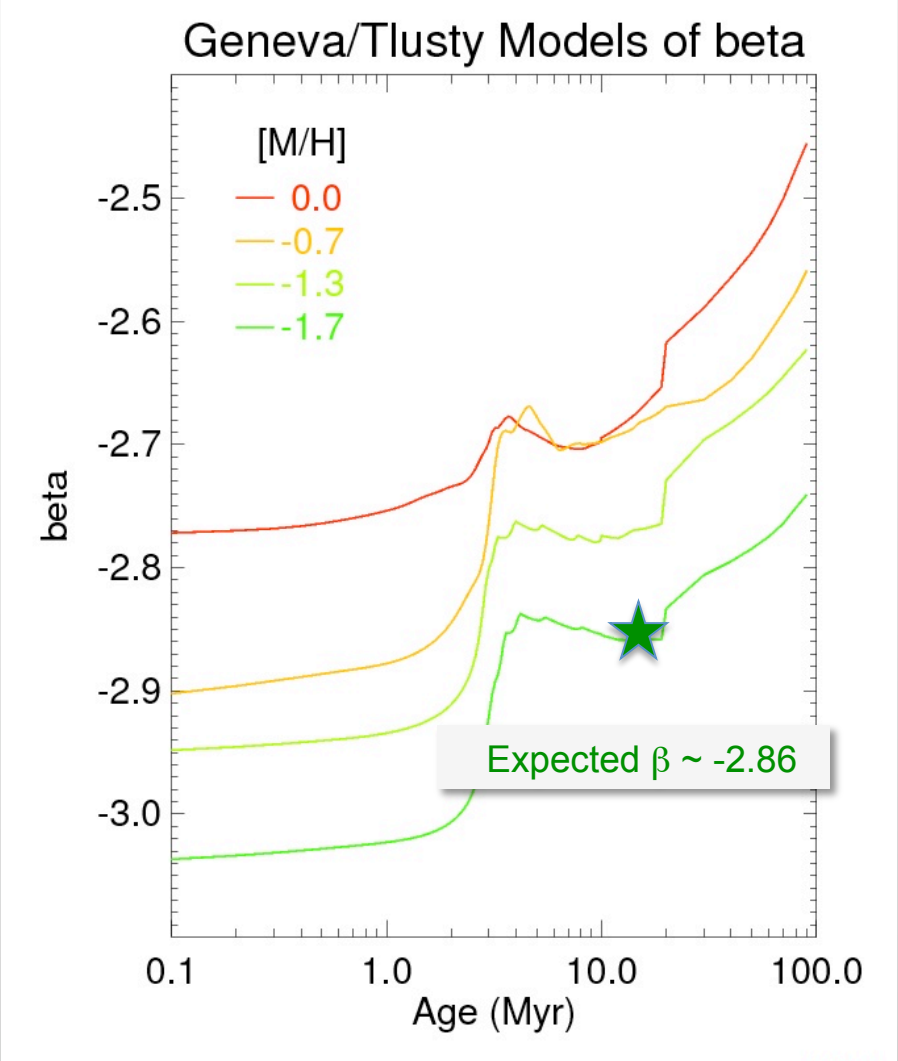
The COS spectrum (R~3500) of I Zw 18-NW has a UV slope, β=-2.45



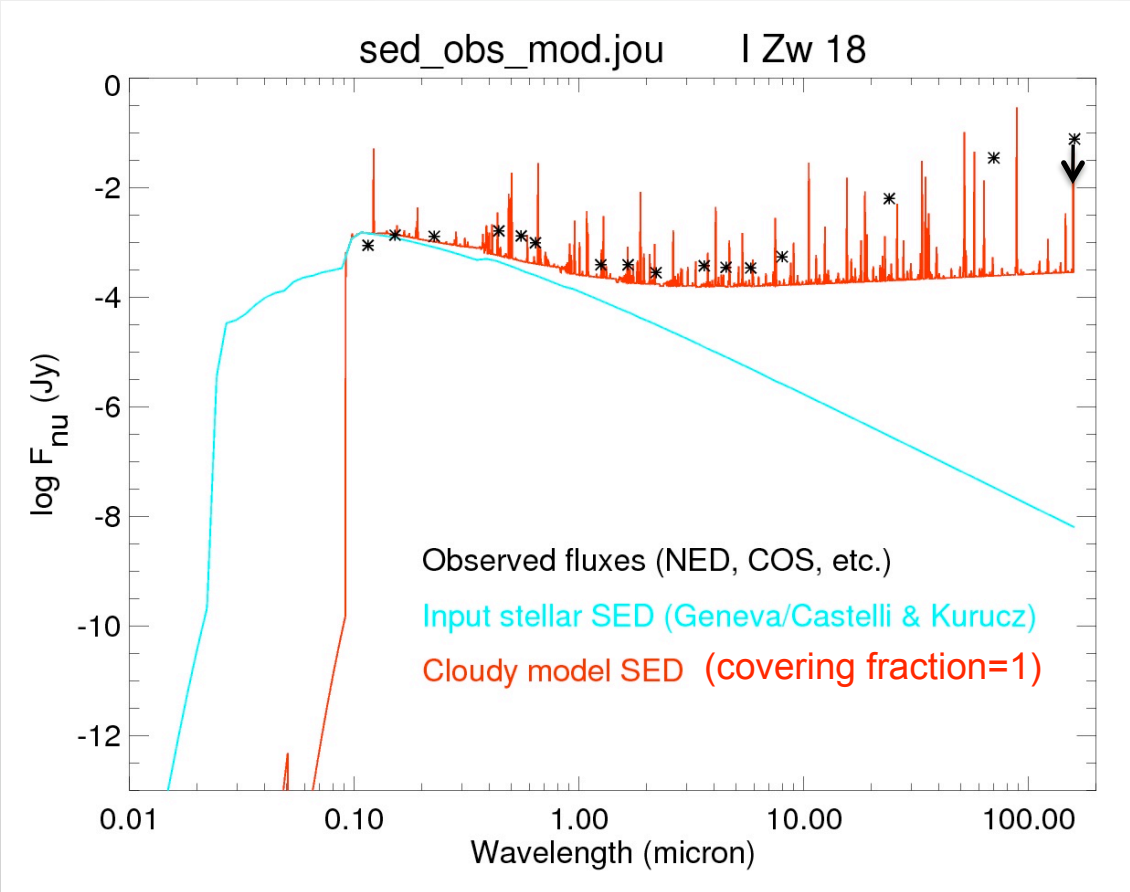
β is sensitive to many factors

β is sensitive to:

- age
- metallicity
- dust extinction
- nebular continuum emission
- covering fraction



Both stars and surrounding H II region influence the UV slope parameter, β

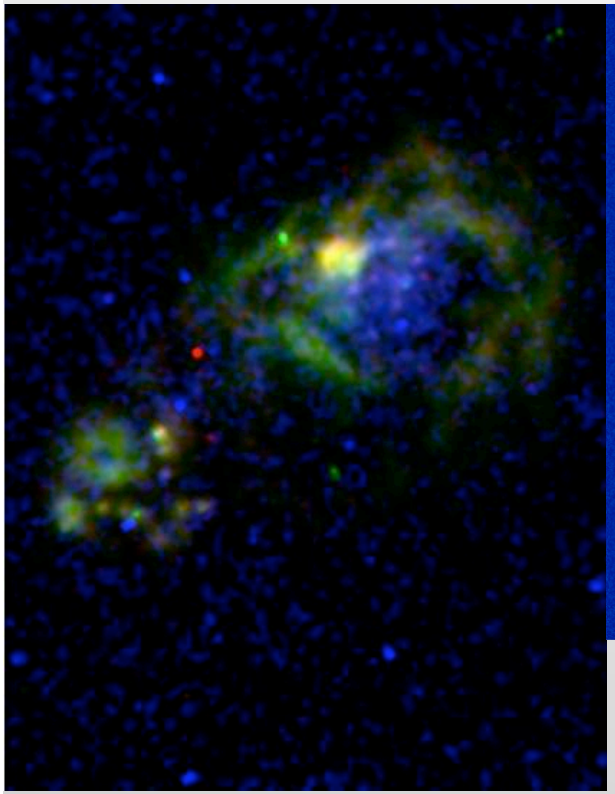


β_{obs}= -2.45

$\beta_{\bigstar}$ = -2.86
-- log $Z/Z_{\odot}$=-1.7
-- age=15 Myr

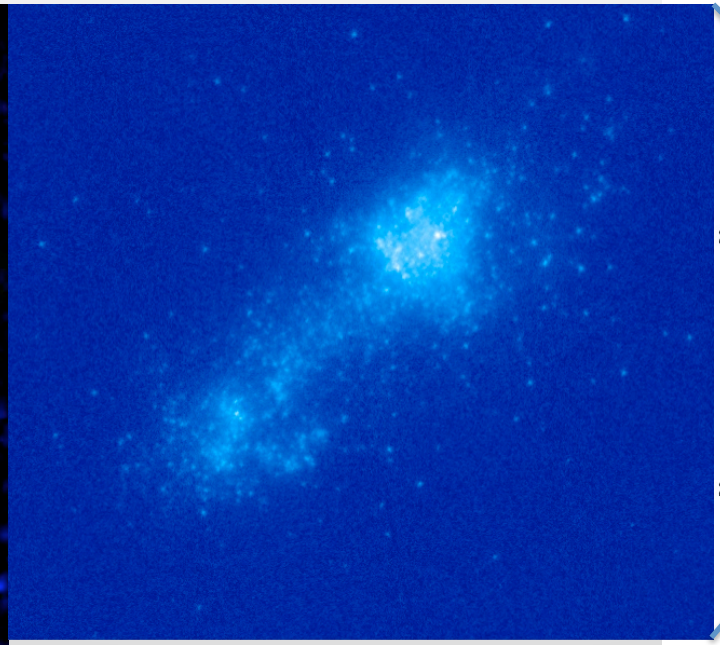
Images of I Zw 18 at different wavelengths show 3 components: stars, HII & HI regions

H II Region



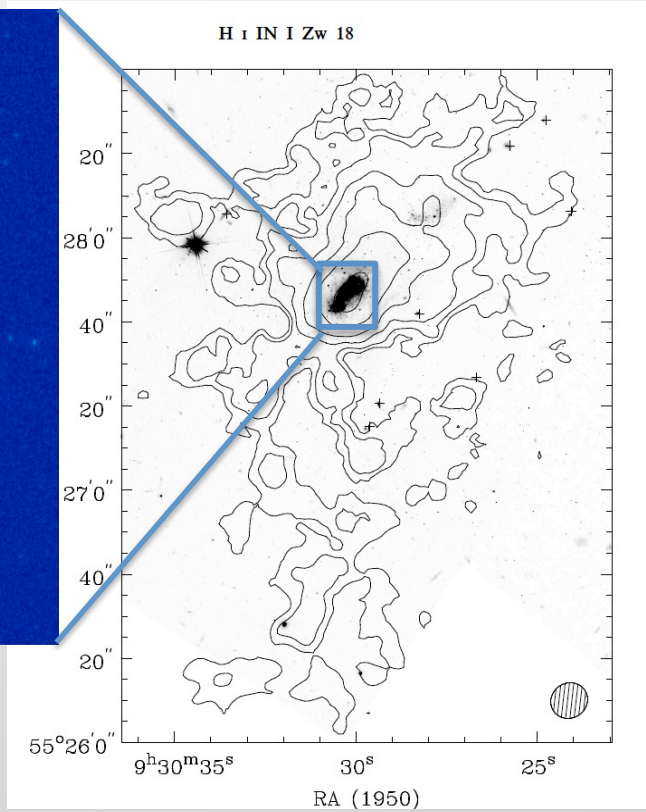
HST/WFPC2
He II F469N
[OIII] F502N
Hα F656N

Young, massive stars



HST/STIS
Far-UV

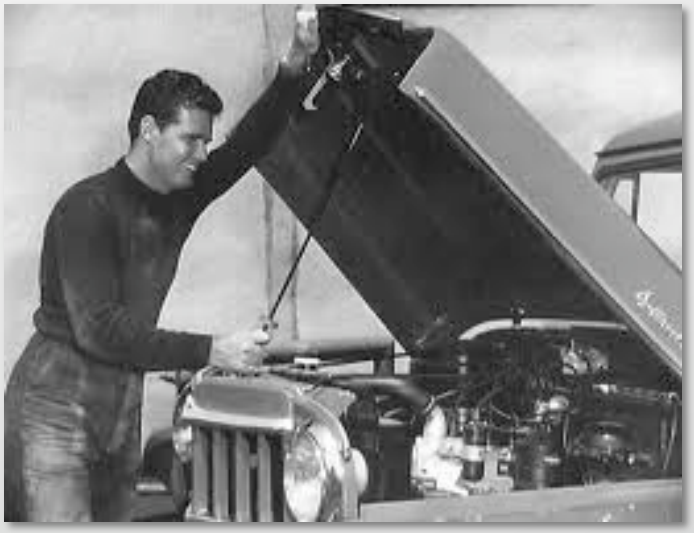
H I Envelope



VLA 21-cm with optical image superposed

The proximity of I Zw 18 allows us to “look under the hood” and see how primitive galaxies evolve

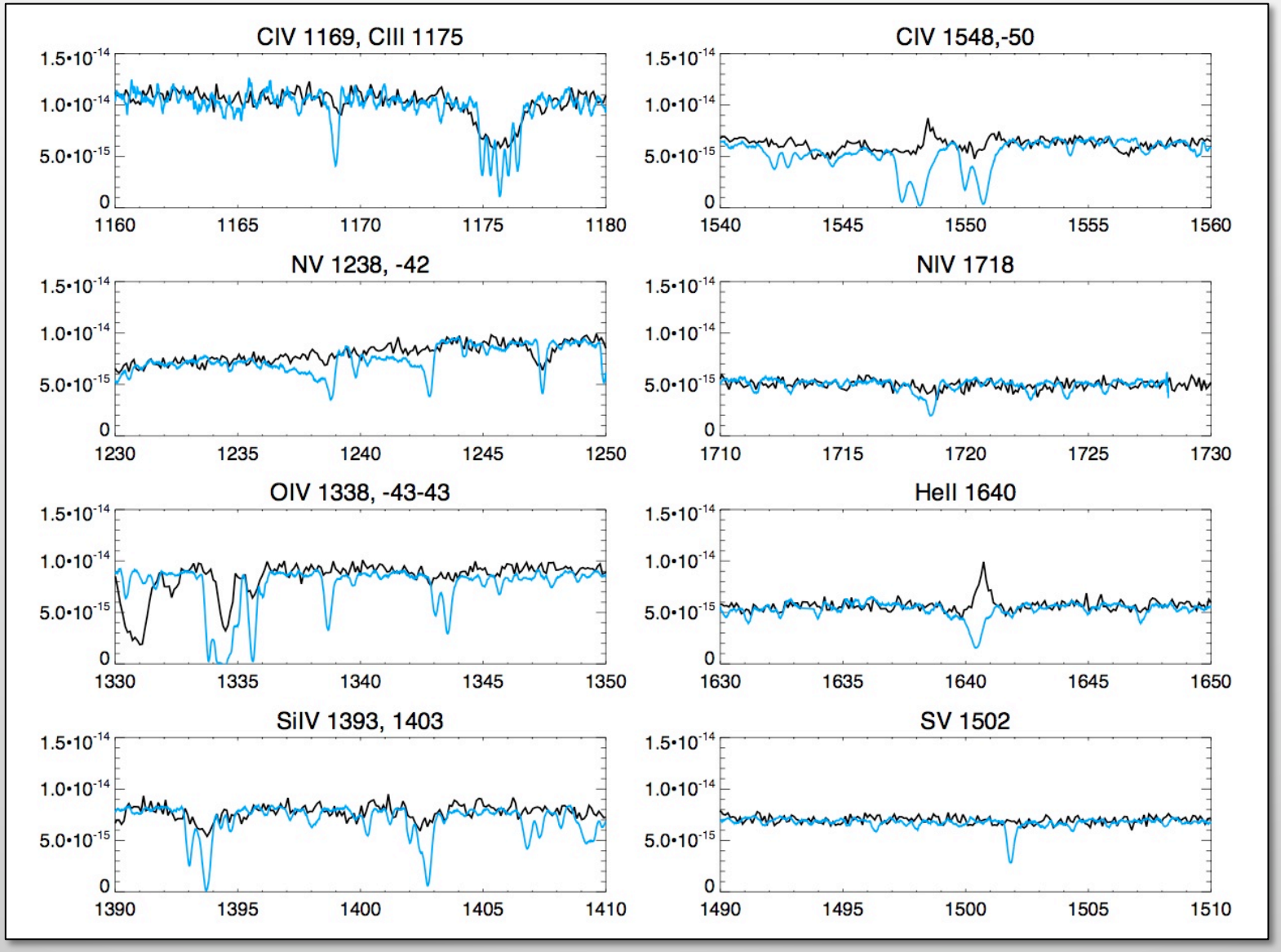
- *Fuel:* The HI envelope supplies material to form stars
- *Engine:* The stars are the internal drivers of galactic evolution
- *Exhaust:* Stellar radiation and ejecta ionize, heat, enrich, and affect the dynamics of the surrounding region



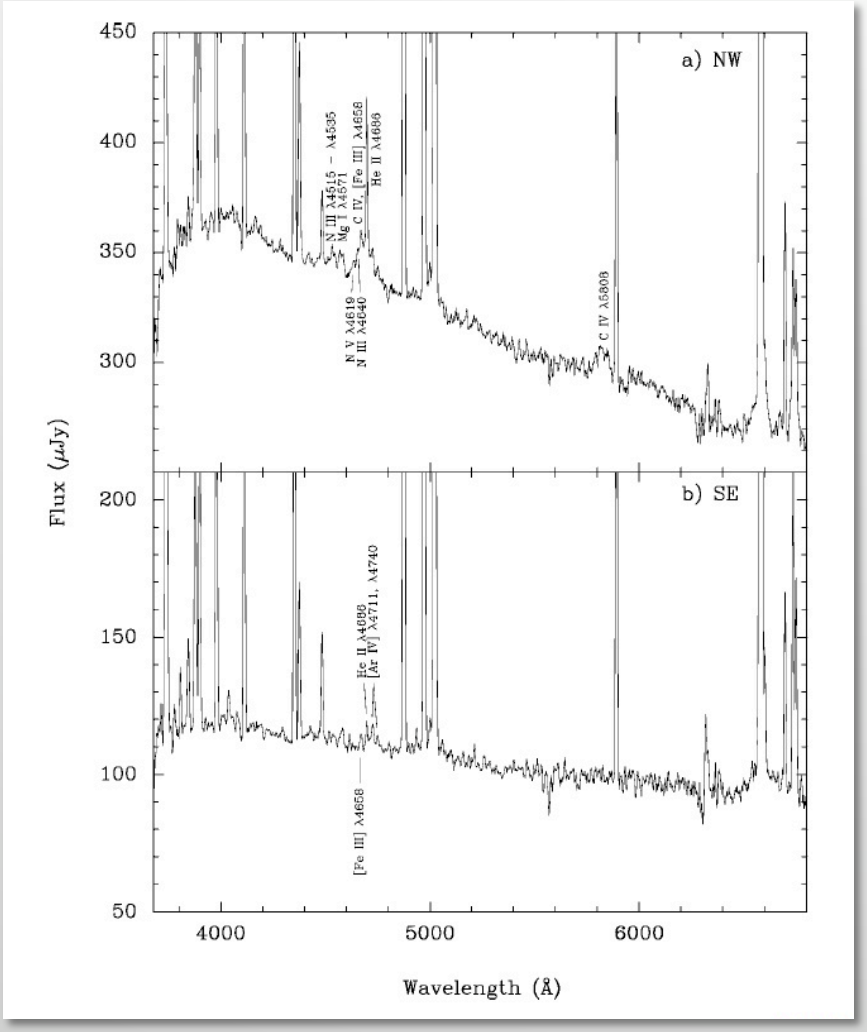
The COS spectrum of I Zw18 gives new information about the stars and HI envelope.
Optical-IR spectra yield the properties of the H II region (Pequignot 2008).

STARS

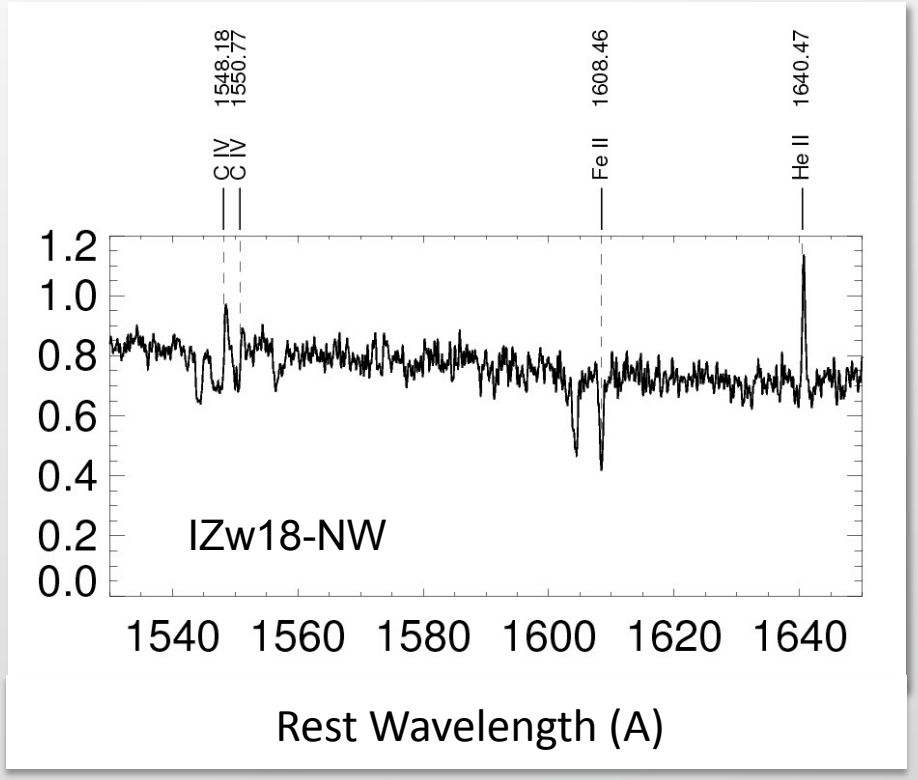
Metal lines in the spectrum of I Zw 18 NW (black) are much weaker than in SMC stars like NGC346-113 OC6vz (blue)



I Zw 18 has Wolf-Rayet stars of type, WC



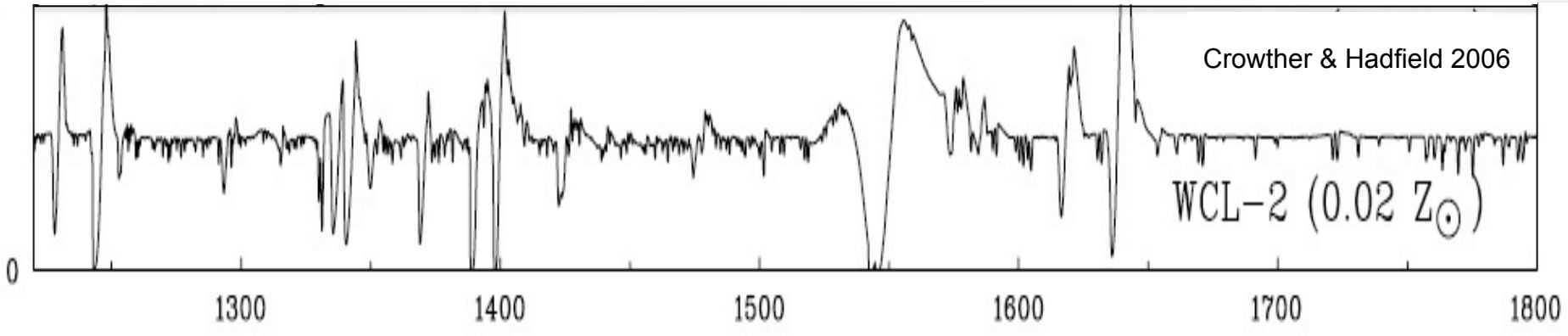
Izotov+97
(also Legrand+97)

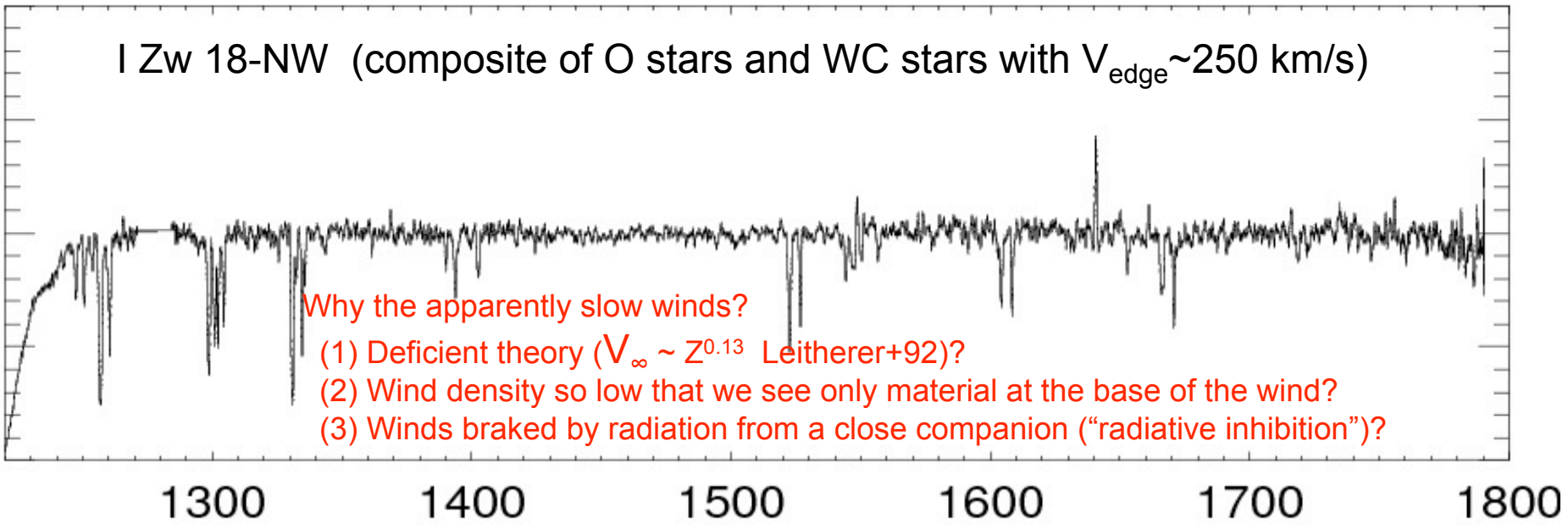


COS Spectrum

Stellar Winds of Stars in I Zw 18 are Much Weaker & Slower than Predicted

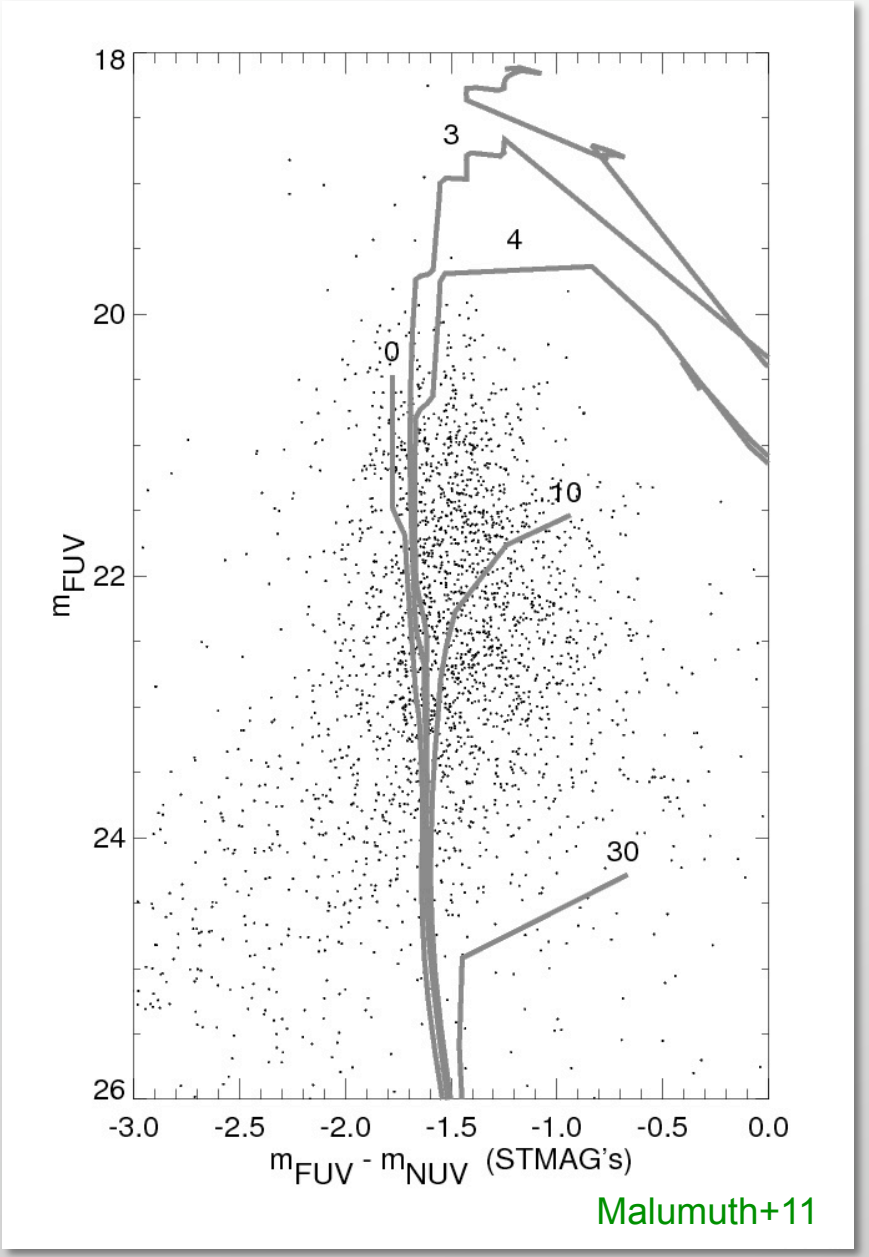
Model Spectrum of a Z=0.02 $Z_\odot$ WC star ($T_\star$=50 K, log $L/L_\odot$=4.9, log$M/M_\odot$ yr^{-1}=-5.8, V_∞=1050 km/s)





UV Color-Magnitude Diagram of I Zw 18

- The CMD based on HST/STIS UV imagery (Brown et al. 2002)
- The high spatial resolution in the UV (0.025 “/pix) enables photometry of stars in I Zw 18
- The model isochrones are based on evolutionary tracks for $Z/Z_{\odot}$=0.0004 (log $Z/Z_{\odot}$=-1.7, $M/M_{\odot}$=0.8-150) (Lejeune & Schaerer 2001)
- The spread of stars on the CMD consistent with a very low metallicity and continuous star formation
- The two brightest stars are WC stars
- Are the brightest stars binary?



Malumuth+11

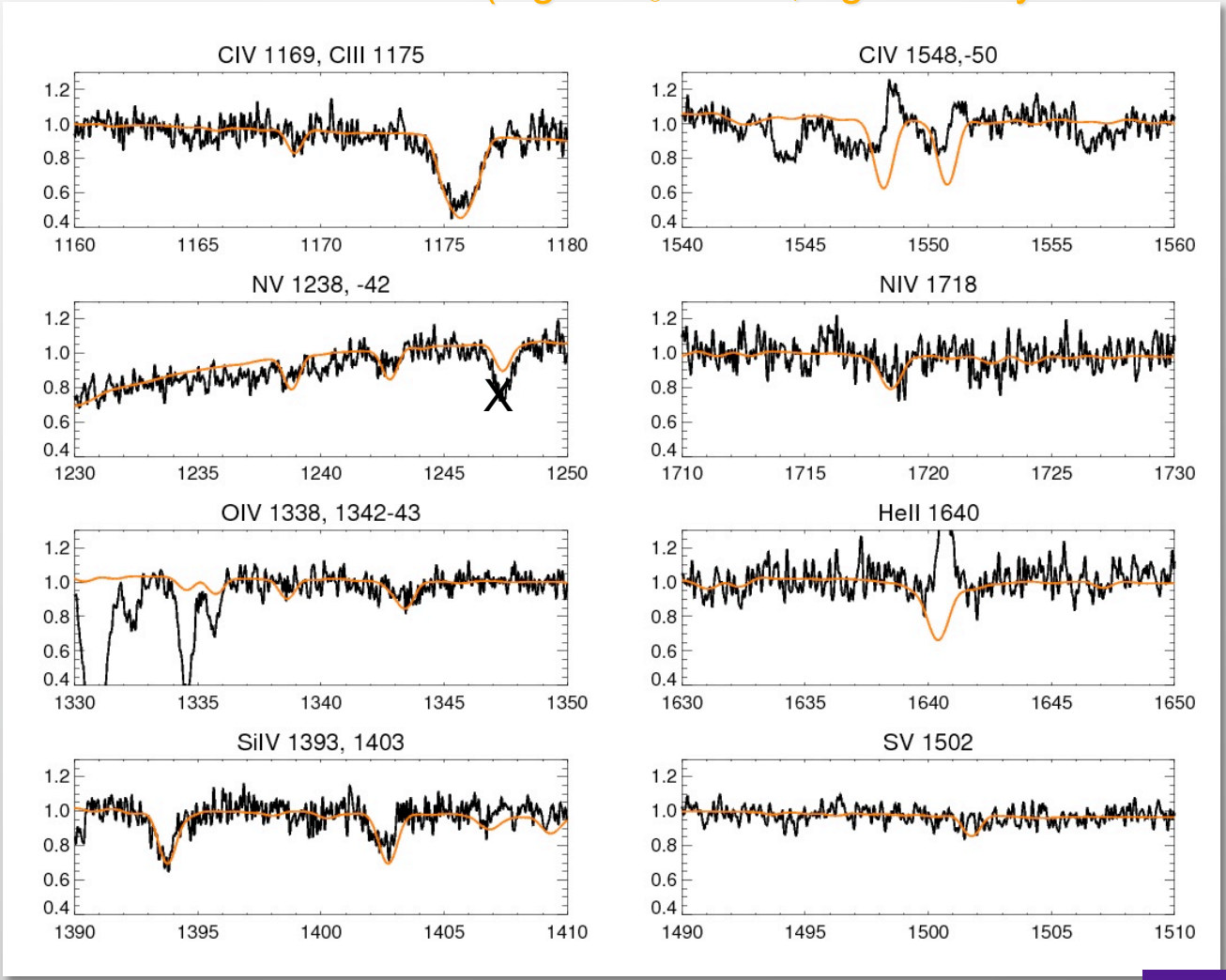
Stellar Features in the COS Spectrum of I Zw 18-NW

----- observations

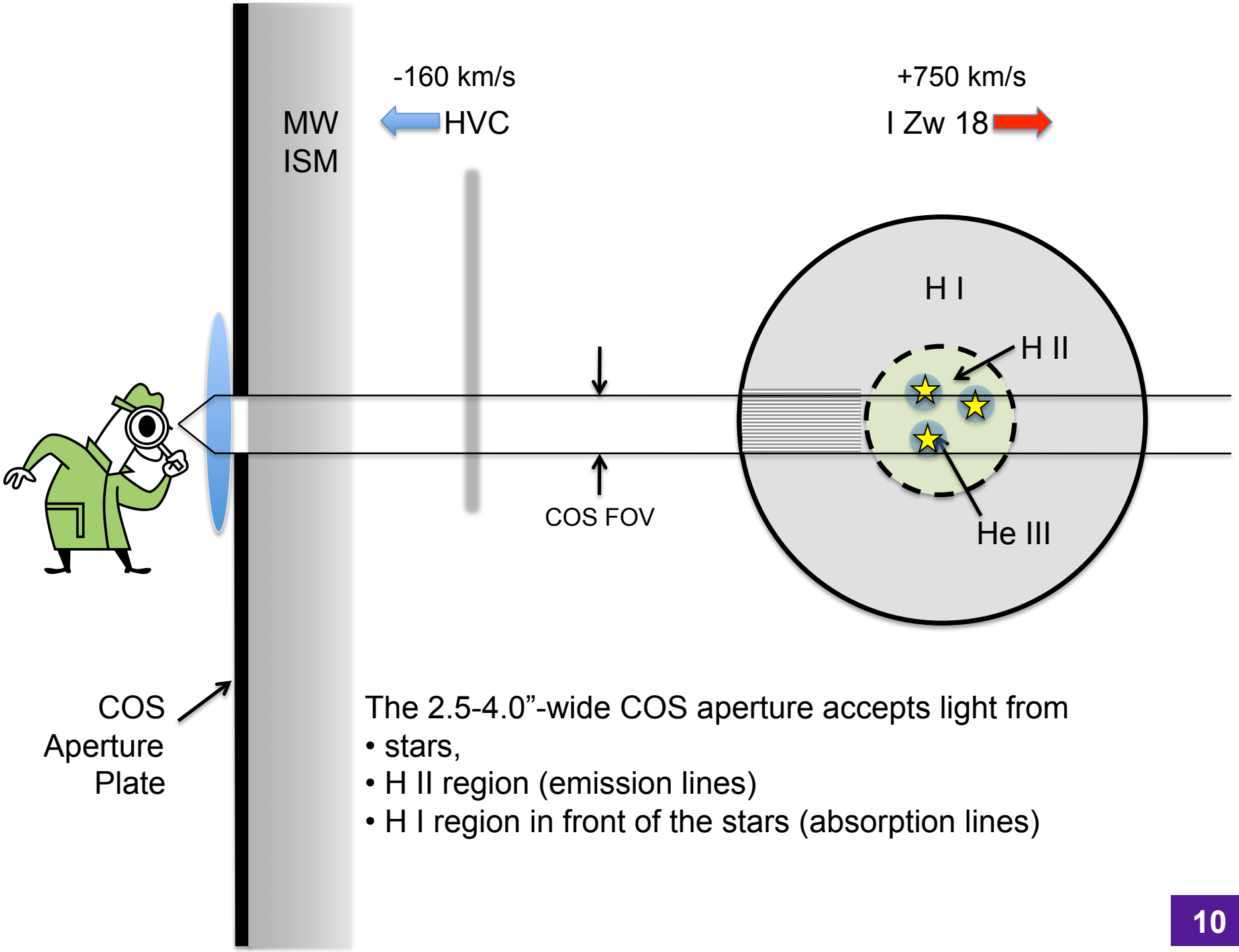
----- stellar model (log $Z/Z_{\odot}$ = -1.7, age=15 Myr

NOTES

- Spectrum is a composite of OB stars and WR stars
- C IV 1549 and He II 1640 are signatures of WC stars
- No sign of WN stars
- Age and metallicity based on C IV 1169 and CIII 1175
- Composite spectrum assumes Salpeter IMF, M_{max}=150 $M_{\odot}$



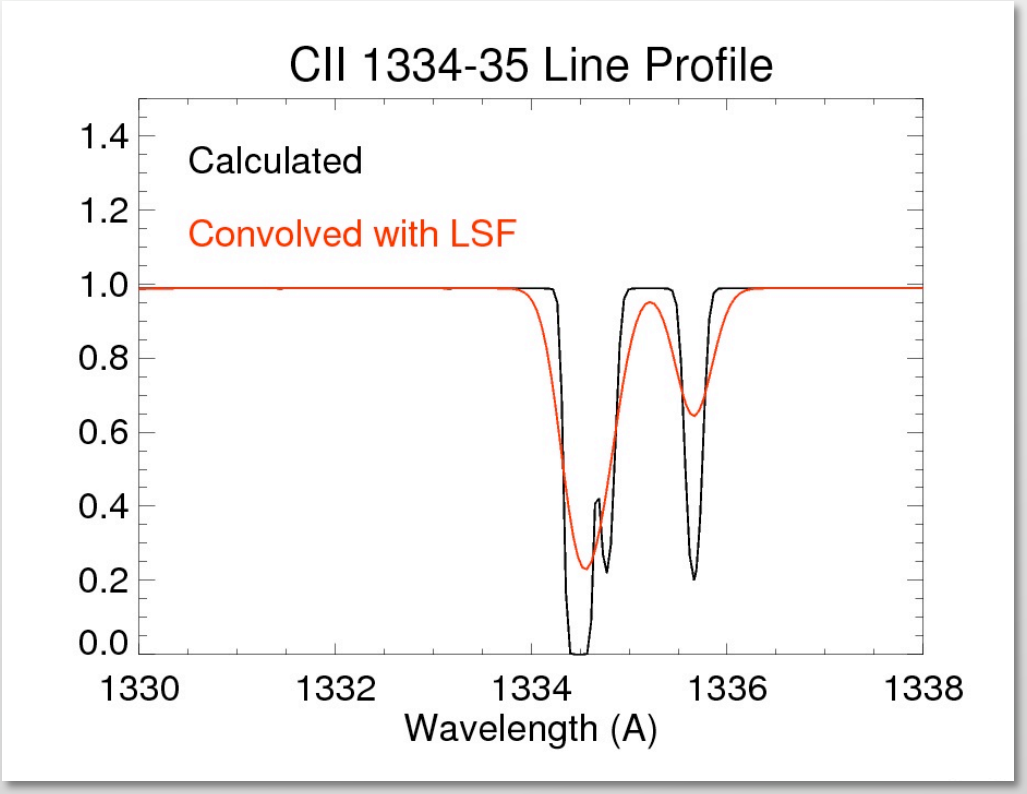
H I Envelope



The 2.5-4.0”-wide COS aperture accepts light from
- stars,
- H II region (emission lines)
- H I region in front of the stars (absorption lines)

Analysis of Lines Arising in the H I Envelope: The Example of C II 1334-5

1. Saturation
2. Ionization correction
3. Stellar absorption
4. Nebular emission



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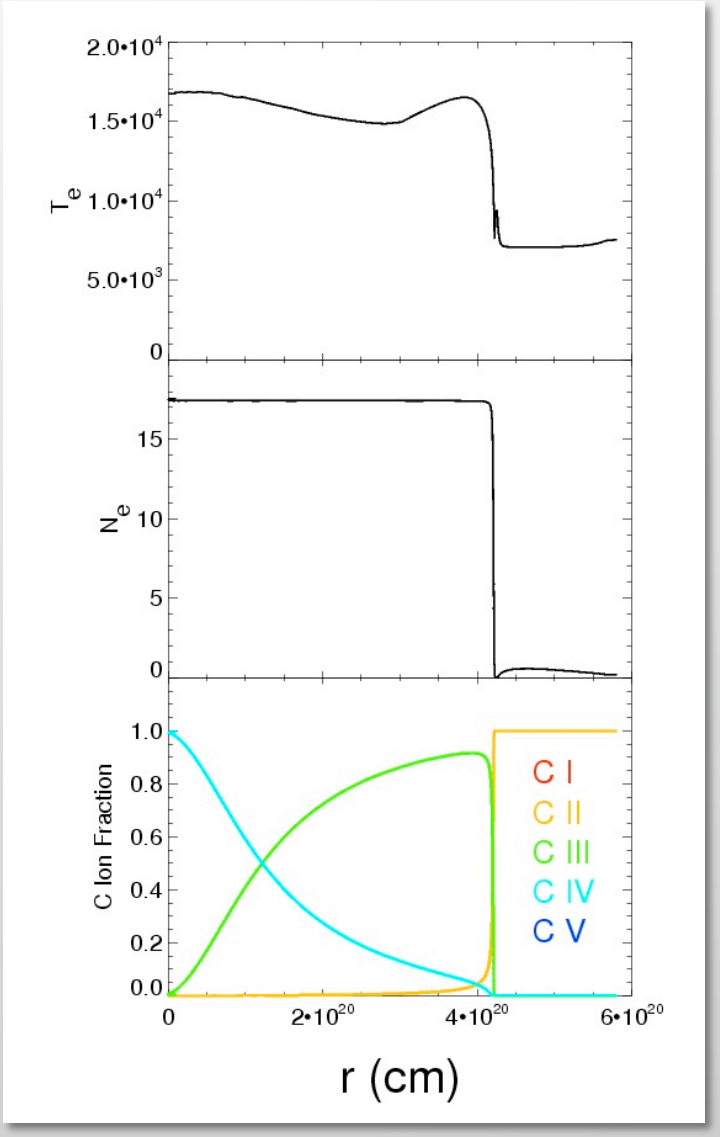

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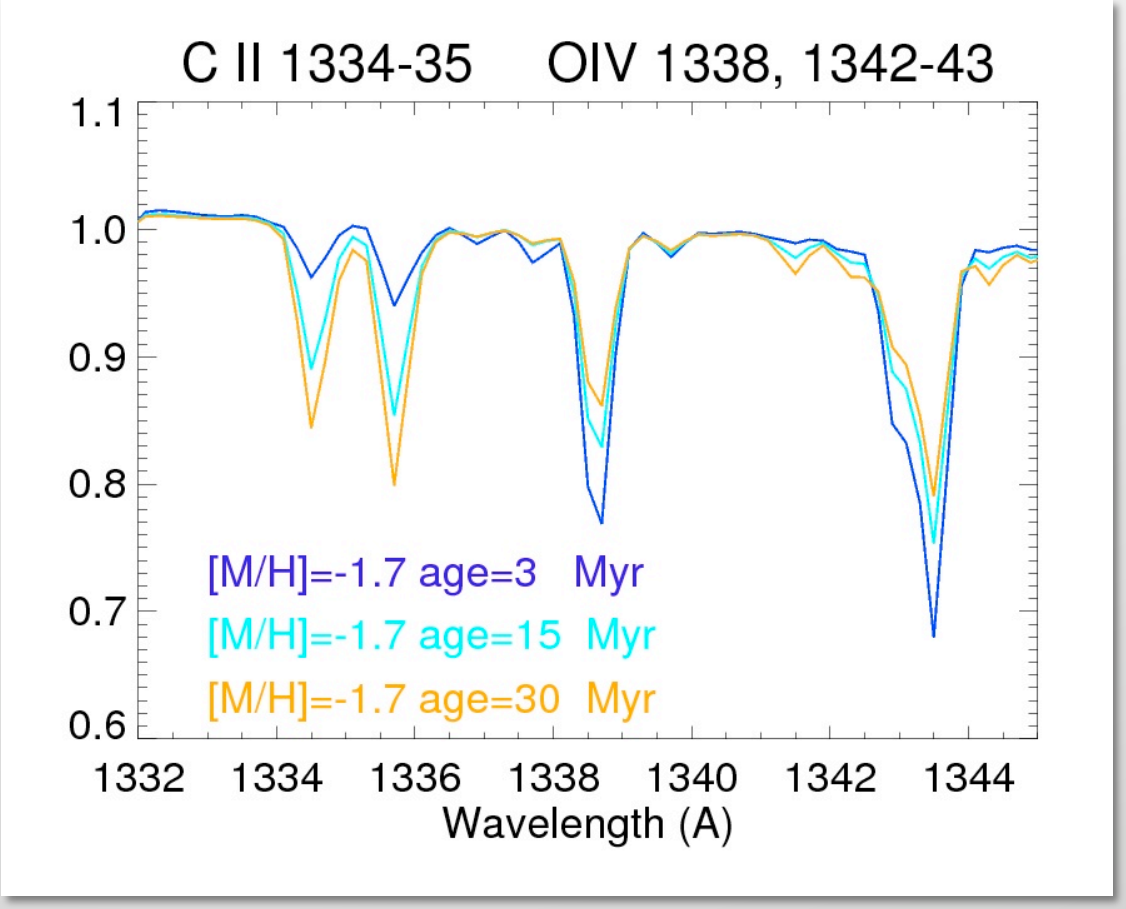
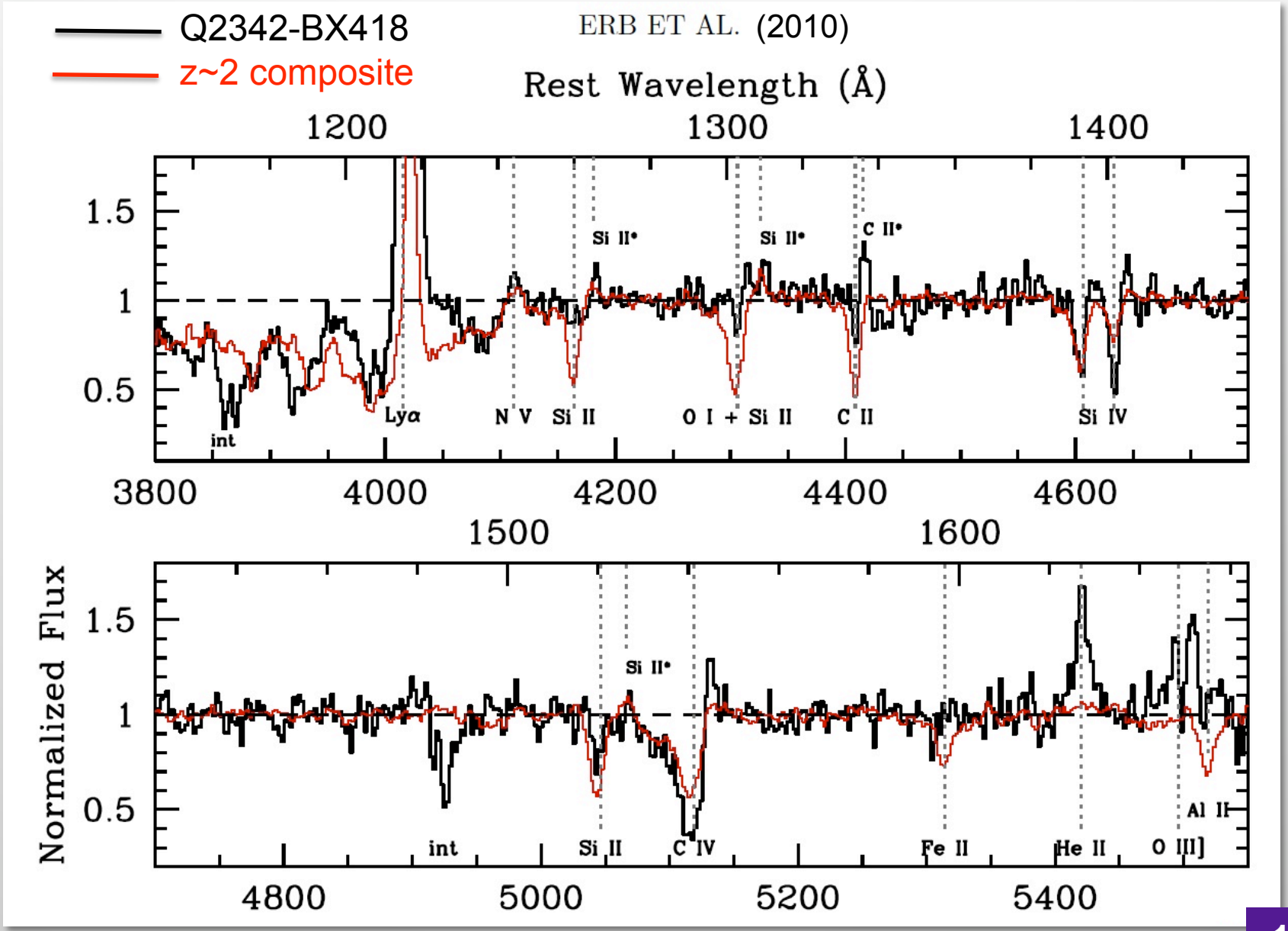


4. Nebular Emisson

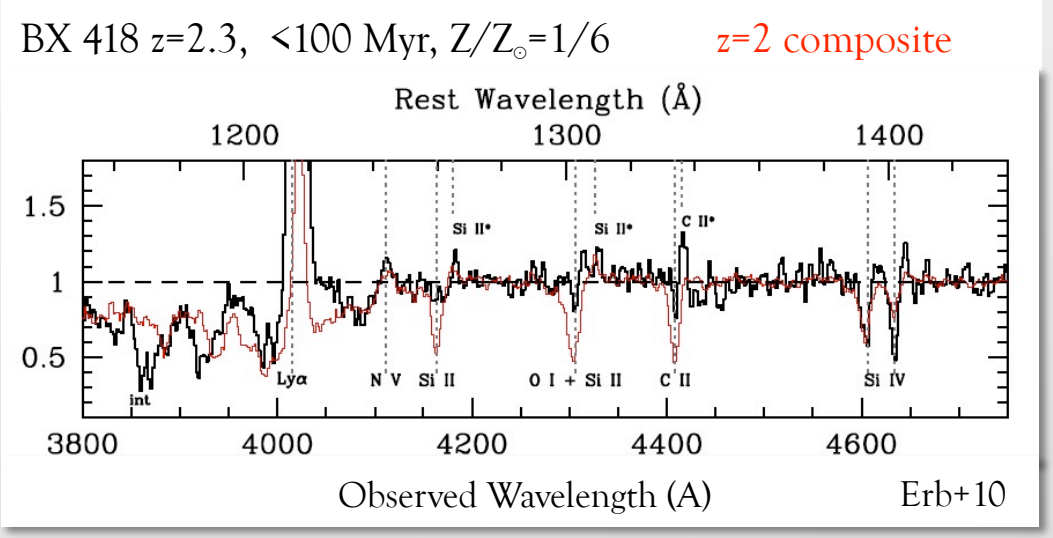


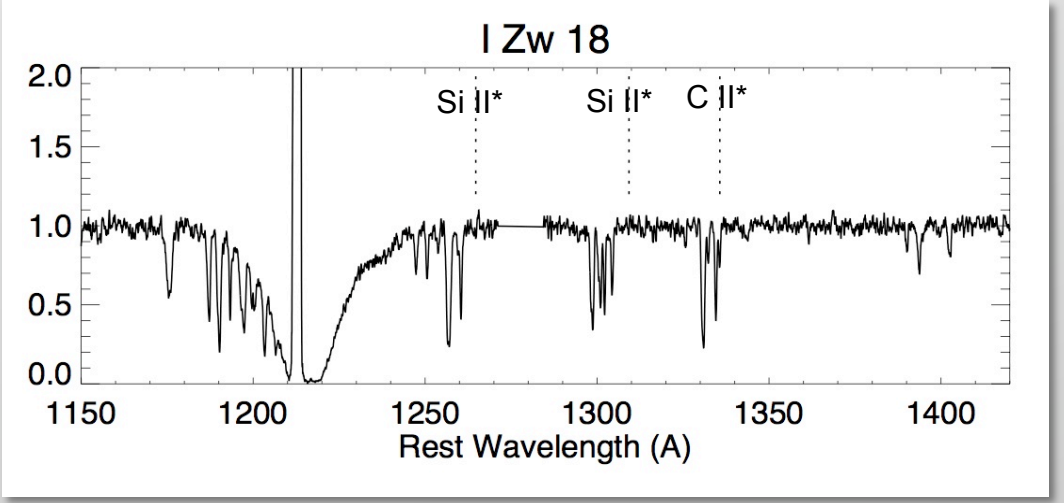
No Significant Gas Outflow from I Zw 18

- P-Cygni-like profiles of Si II, C II fine-structure lines
- Velocity offset of absorption lines, v = -91 km/s in the H I region
- Blue-shifted absorption component eats away the blue side of the nebular emission; only the red side remains

Velocity offset of H I-region near 0 km/s

- Nebular emission in the fine-structure lines fills in the absorption component





Abundances in H I Region Derived with Cloudspec

Preliminary!

Elem	[X/H] H I	[X/H] H II
C	-2.83	-1.84
N	-2.74	-2.18
O	-1.95	-1.45
Al	-2.45	
Si	-2.05	-1.62
S	-2.68	-1.57
Fe	-1.87	-1.82

LEGEND

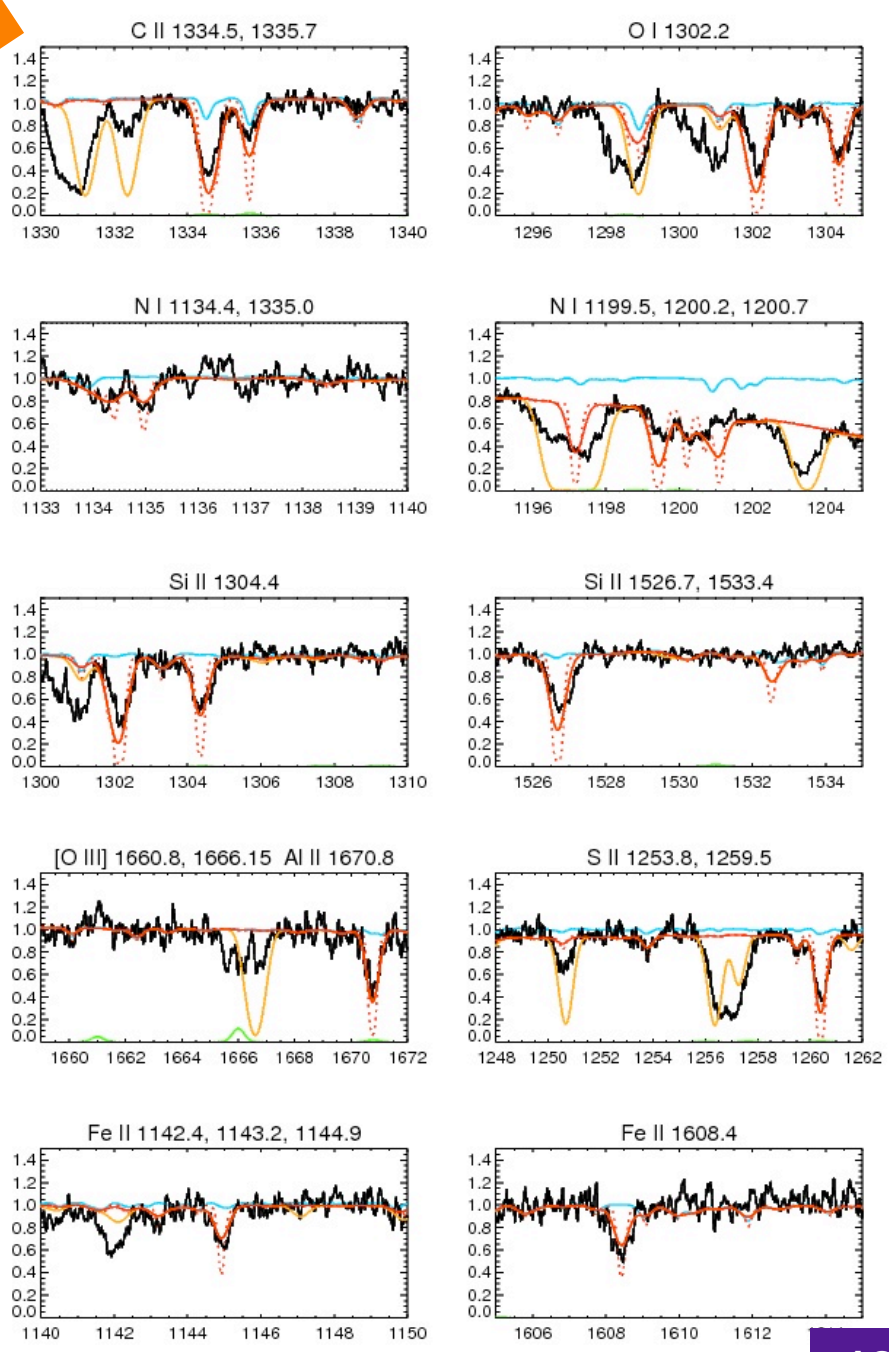
Black – observed spectrum

Red – model spectrum

Red dotted – calculated spectrum (no convolution with LSF)

Blue – stellar spectrum

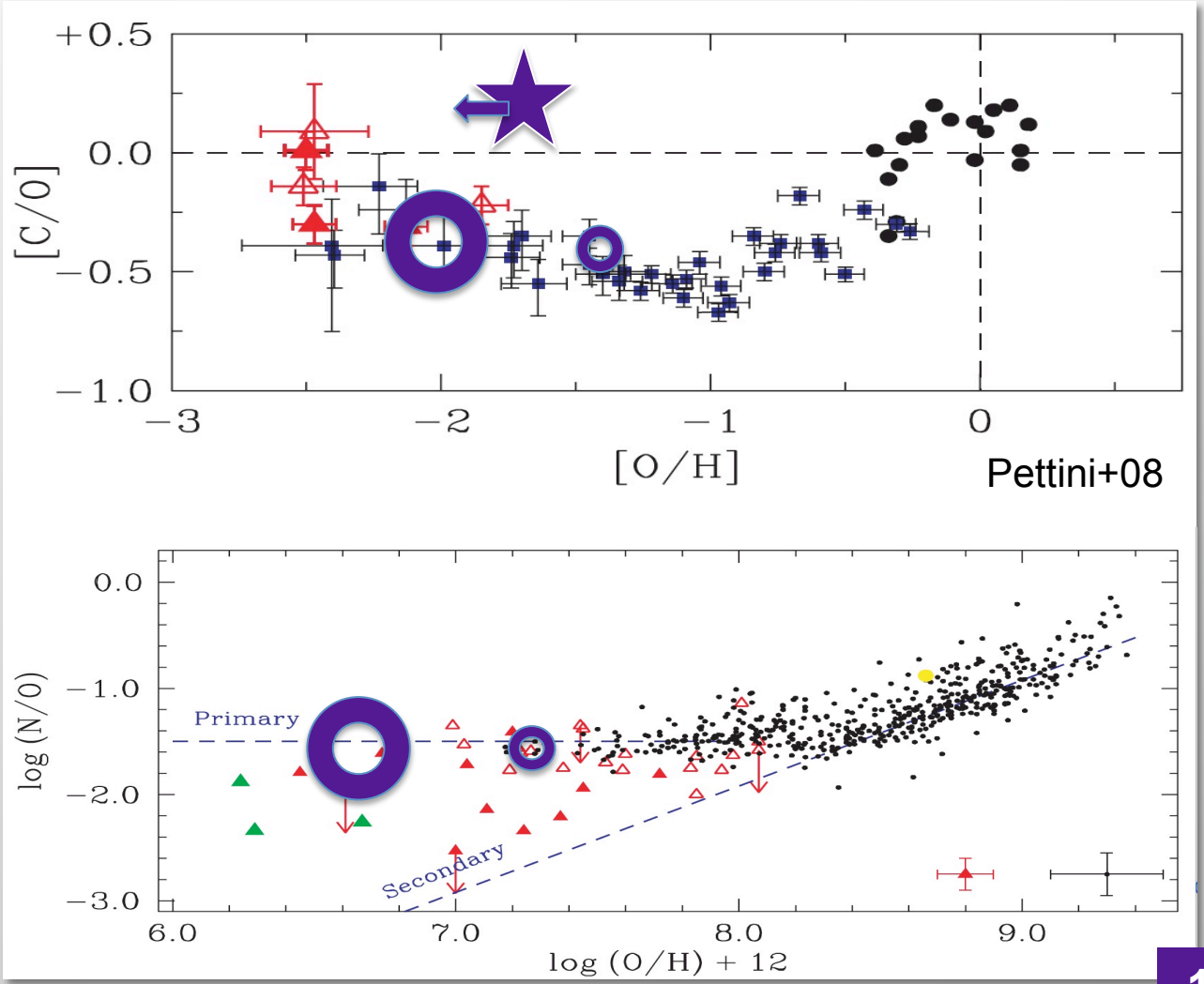
Orange – spectrum of MW & HVC



Abundance Ratios in Low-Metallicity Objects

Symbols

- HII Regions
- MW disk stars
- MW halo stars
- DLA's
- Sub-DLA's
- I Zw 18 stars
- I Zw 18 HII region (Pequignot 08)
- I Zw 18 HI region



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