METAL-POOR MASSIVE STARS

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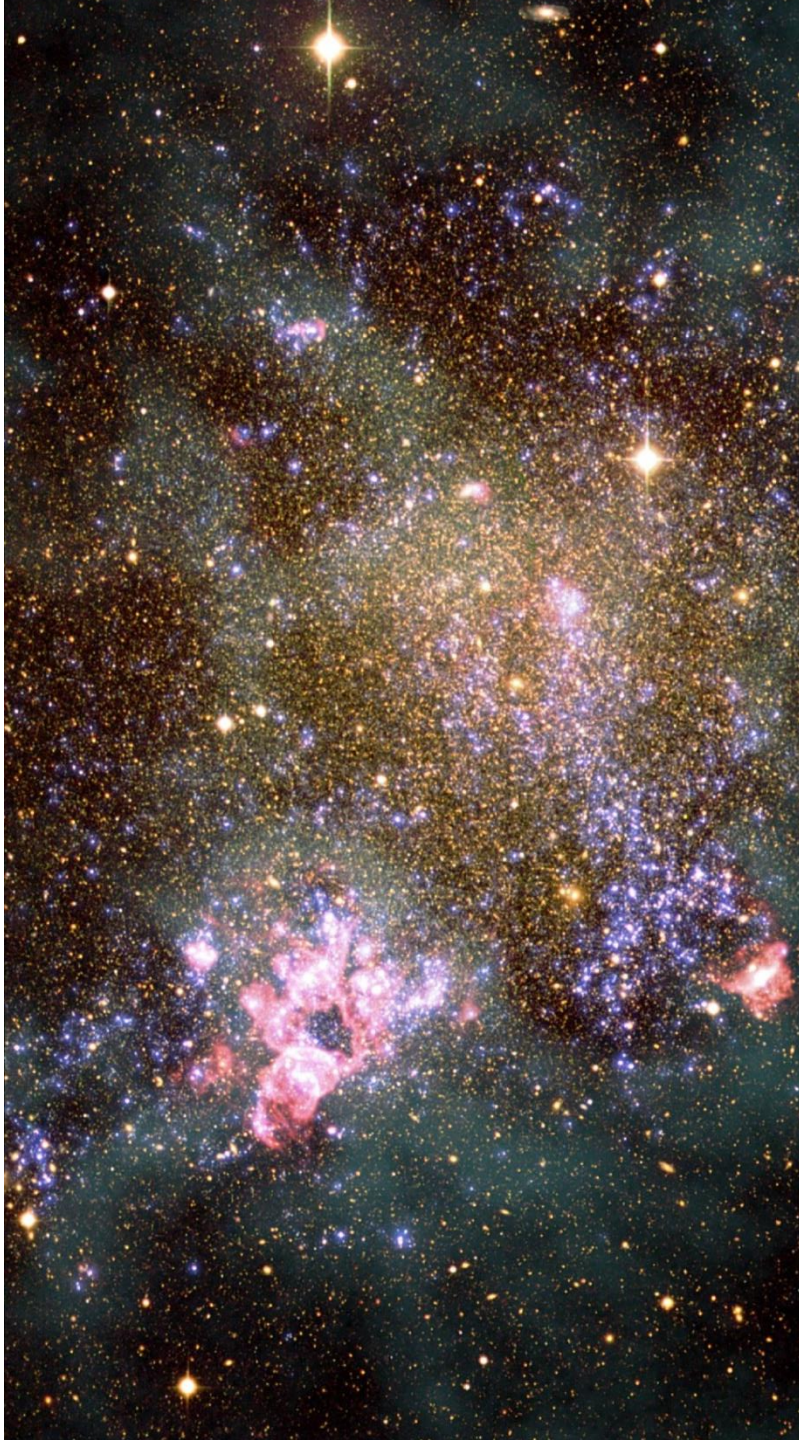
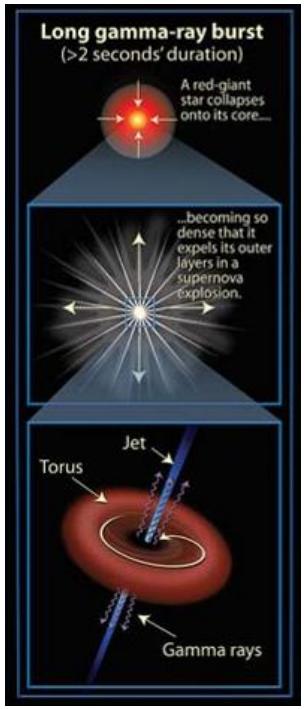
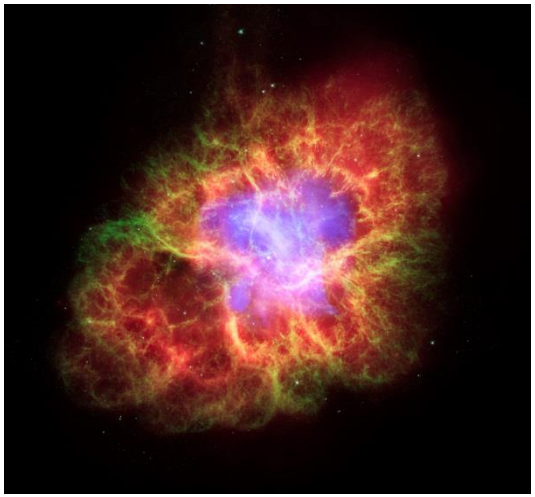
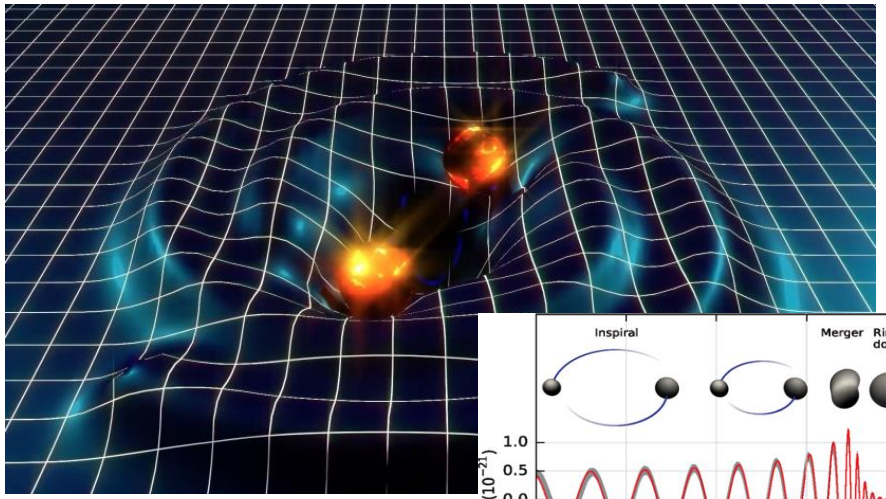


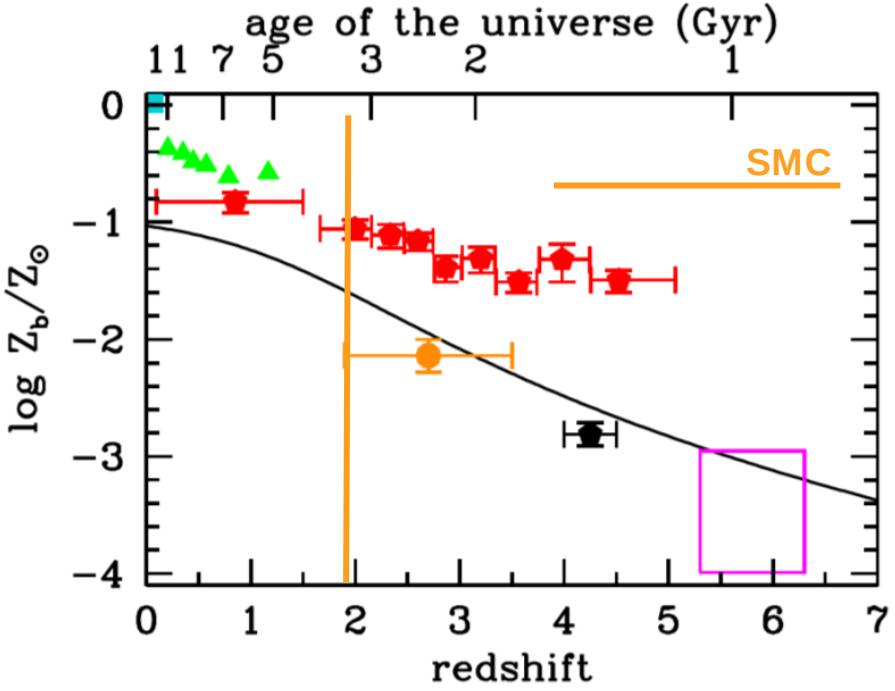

Long gamma-ray burst
(>2 seconds' duration)
A red-giant star collapses onto its core....
...becoming so dense that it expels its outer layers in a supernova explosion.
Jet
Torus
Gamma rays





Inspiral
Merger
Ring-down
1.0
0.5
0.0
-0.5
-1.0
Strain (10^{-21})
Numerical relativity
Reconstructed (template)
0.30
0.35
0.40
0.45
Time (s)

WHY LOW-Z (sub-SMC) MASSIVE STARS?

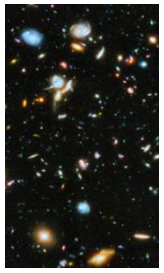


Madau & Dickinson (2014)

- Understanding the process that rule (or otherwise) the physics of massive stars at the peak of star formation
- Working towards the First Stars, and high-z systems
- Formation of >30$M_\odot$ black holes in binary systems (GW150914)
- Progenitor map for GRBs, SNe, SLSNe in the single-star scenario

↓ METALLICITY = ↑DISTANCE



$Z \sim Z_{\odot}$ → $Z \sim 0$

LMC
1/2 $Z_{\odot}$
50 Kpc

SMC
1/5 $Z_{\odot}$
60 Kpc

IZw18
1/32 $Z_{\odot}$
18.2Mpc

↓ METALLICITY = ↑DISTANCE




Z~ $Z_\odot$ → Z~0

LMC
1/2 $Z_\odot$
50 Kpc

SMC
1/5 $Z_\odot$
60 Kpc

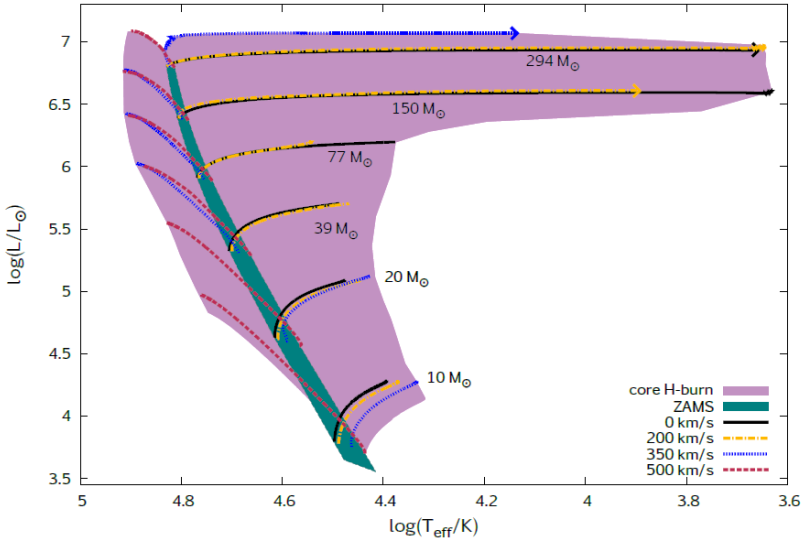
IZw18
1/32 $Z_\odot$
18.2Mpc


IC1613
1/7 $O_\odot$
750Kpc

SEXT-A
1/10 $O_\odot$
1.3Mpc

THREE QUESTIONS TO SOLVE

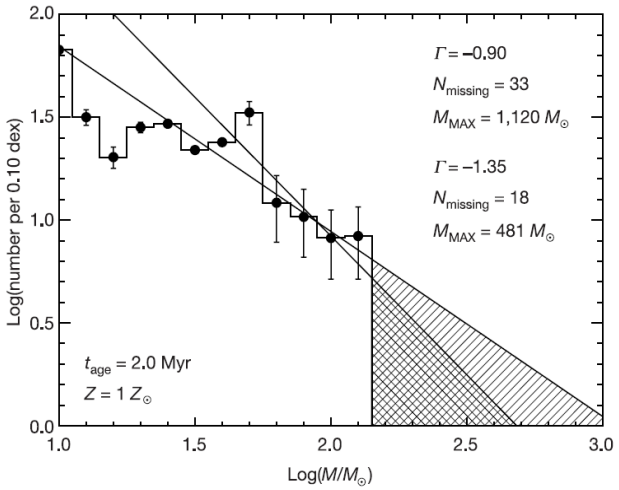
- The incidence of chemically homogeneous evolution at low-Z



Szécsi+ 2015

- Low-Z radiation driven winds
- Low-Z IMF and the upper mass limit?

Figer 2005



PIVOTAL, TWO-FOLD ROLE OF WSO

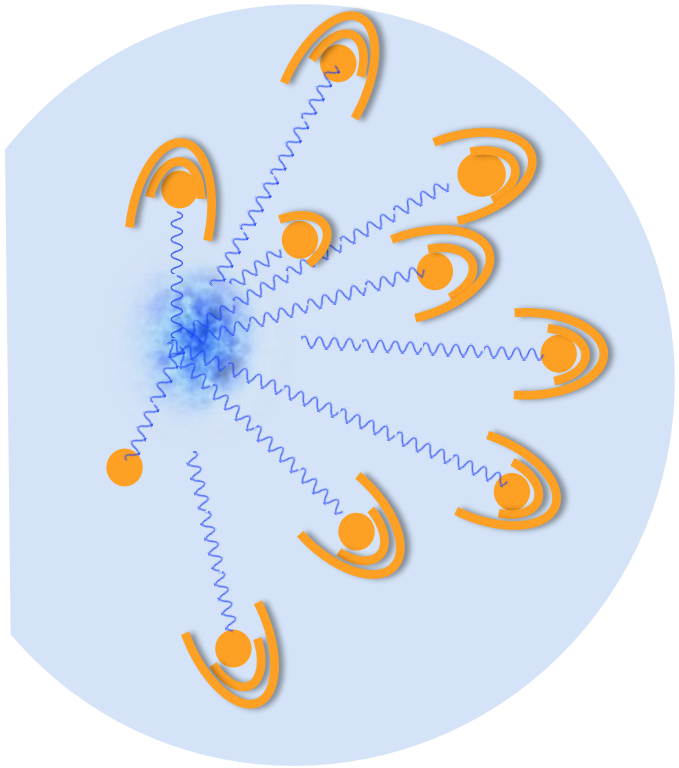
The new challenge ahead: characterize OB stars through the Universe's chemical history

- **LSS:**
  - Characterization of the radiation-driven winds of Low-Z OB stars
  - Constraints on Fe-abundance

- **FCU:**
  - Census and discovery of new blue massive stars

RADIATION-DRIVEN WINDS

- **Hot stages: OB stars, WR, LBVs**
- **Intense UV field**
- **Momentum-transfer to metals (Fe)**



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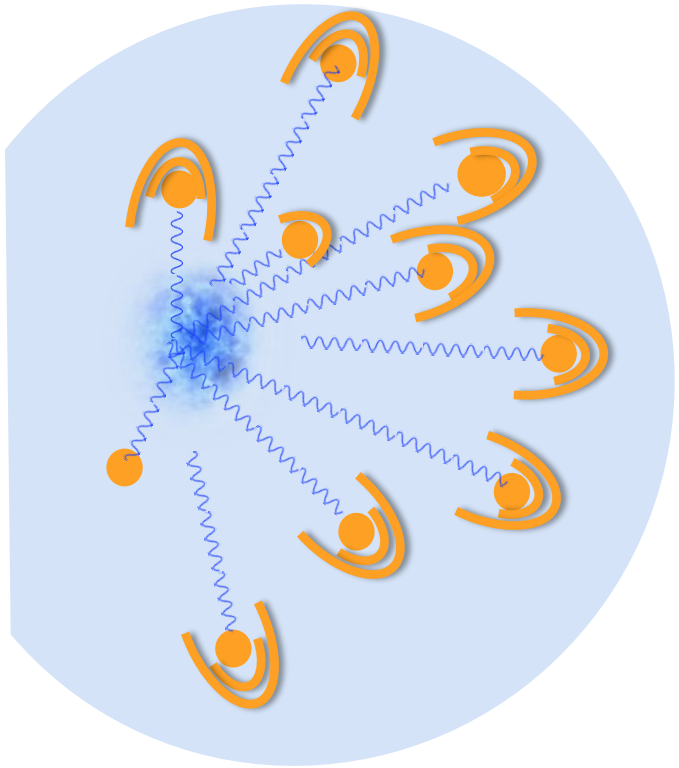
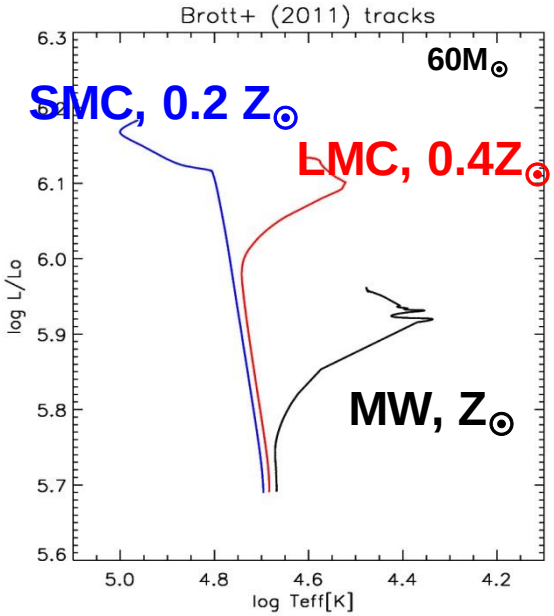


- Metallicity effects on evolution, mostly through stellar wind



Stellar evolution

RADIATION-DRIVEN WINDS

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- Intense UV field
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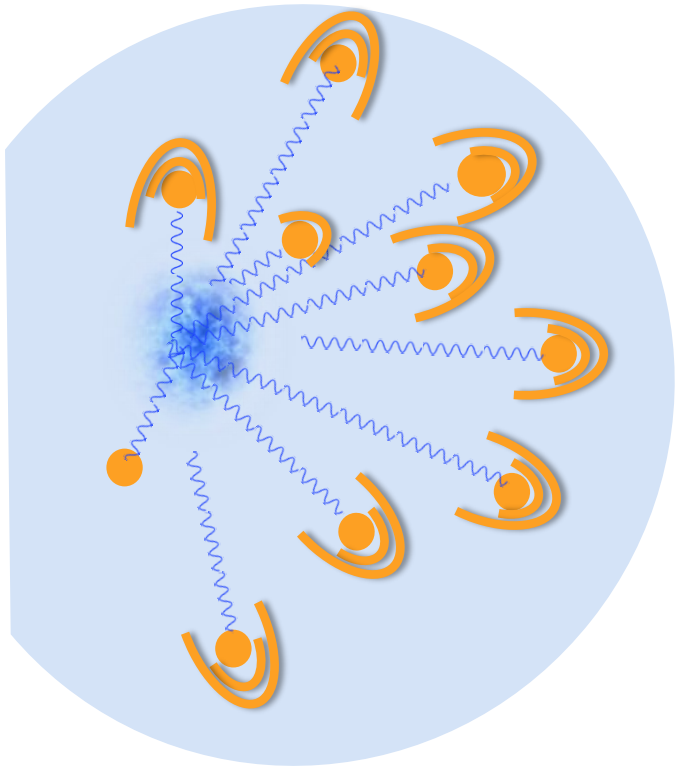

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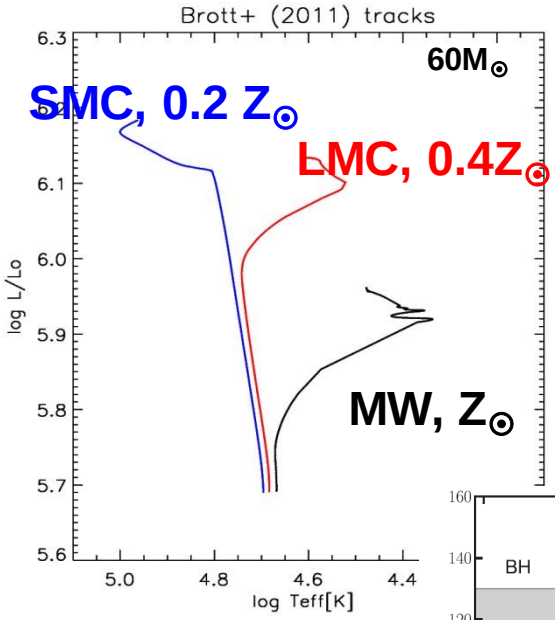
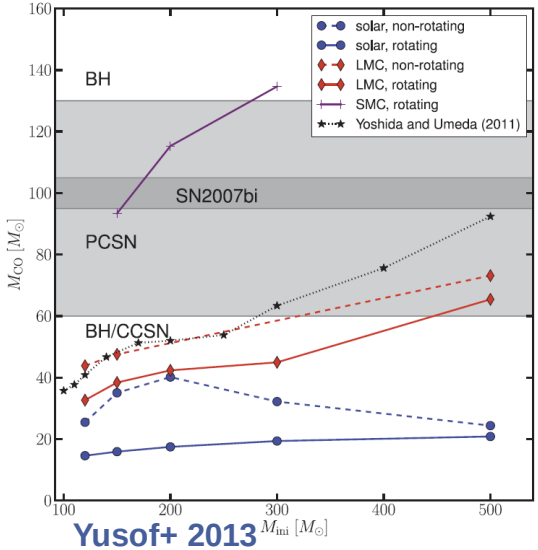


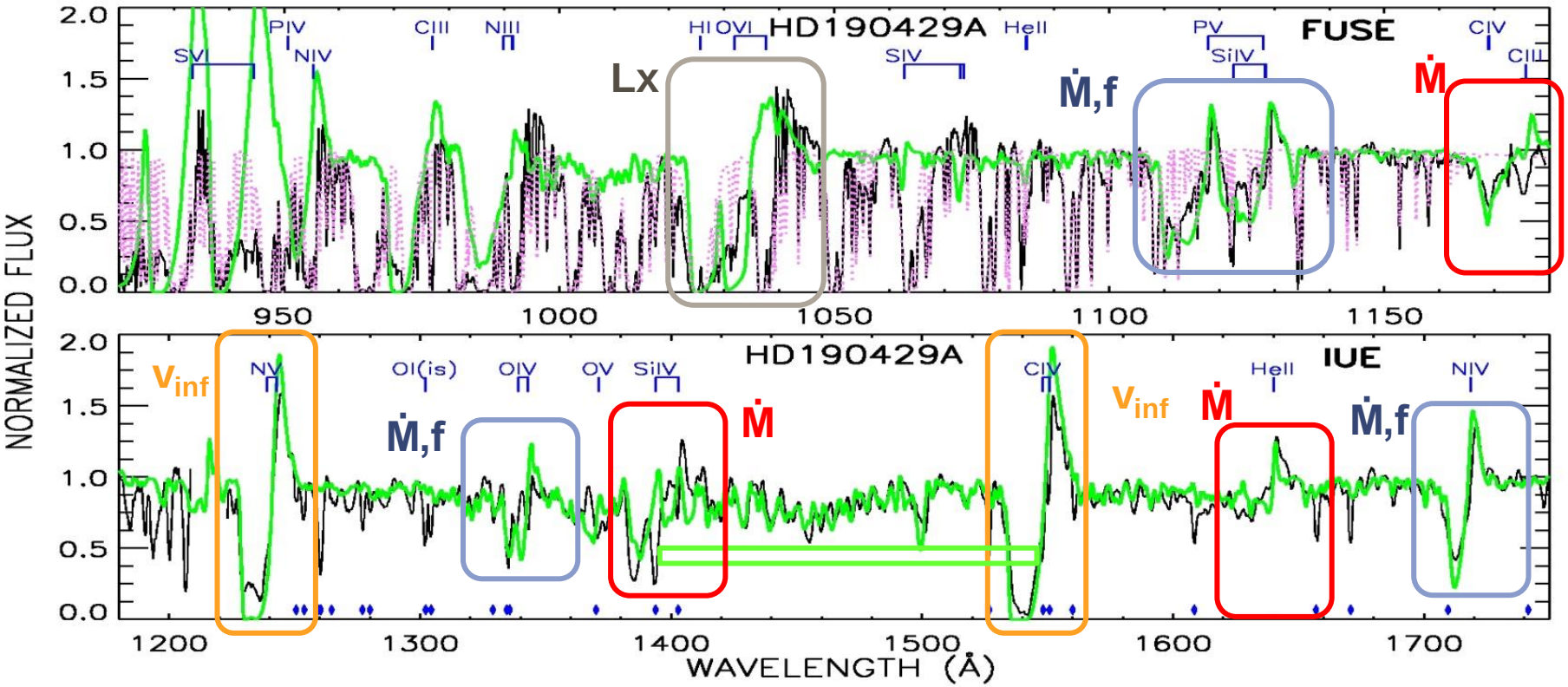
Stellar evolution

End stages



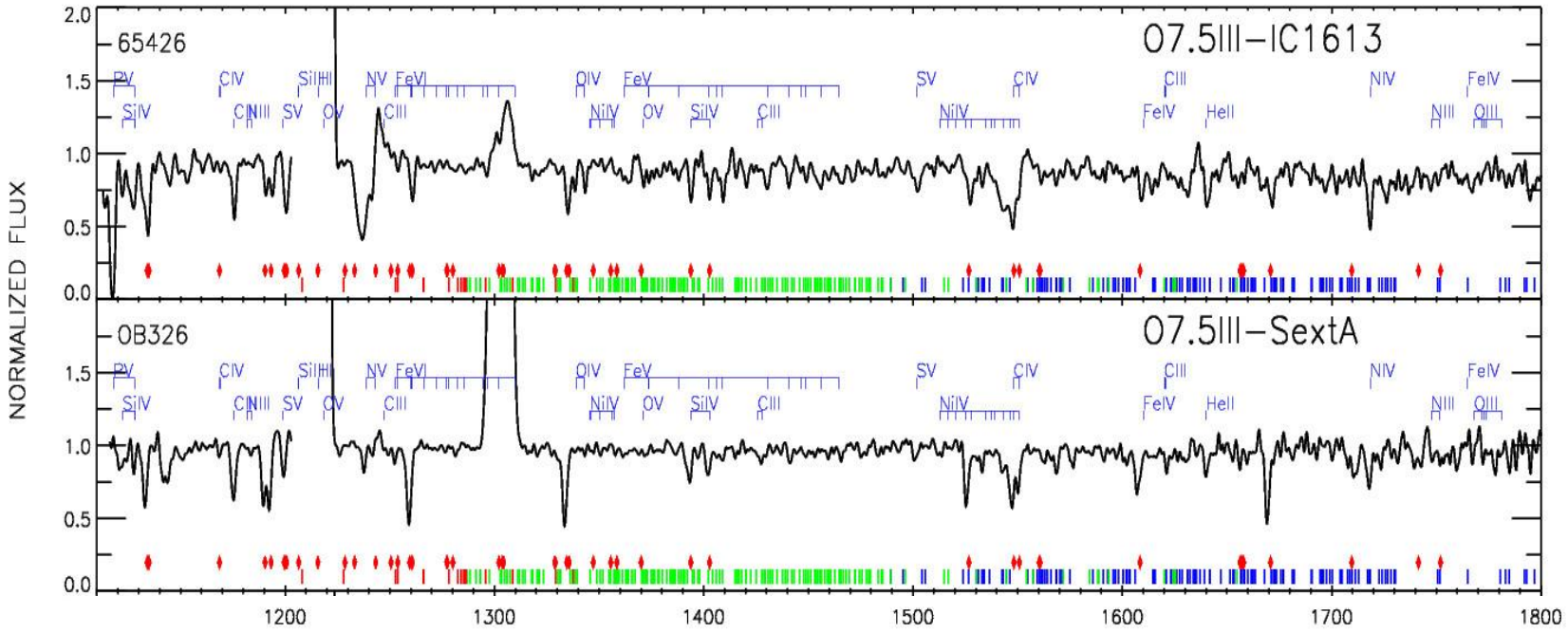
Yusof+ 2013

UV-ANATOMY: MW STARS



Garcia & Bianchi (2004)

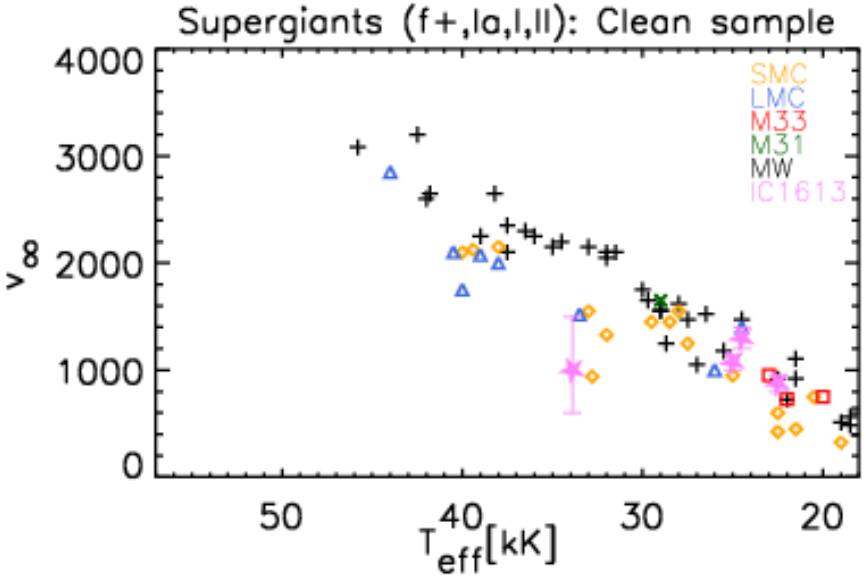
SIGNATURES DETECTED ALSO AT 1Mpc

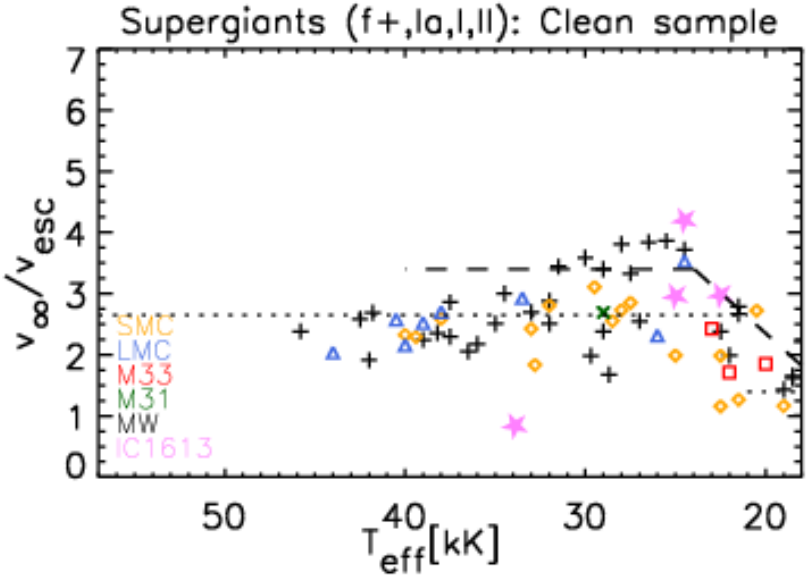


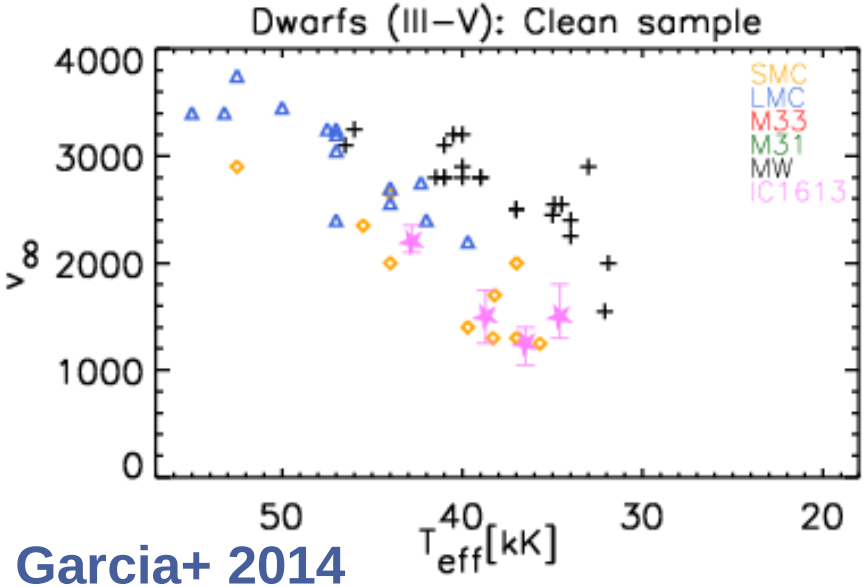
Garcia+ in prep.

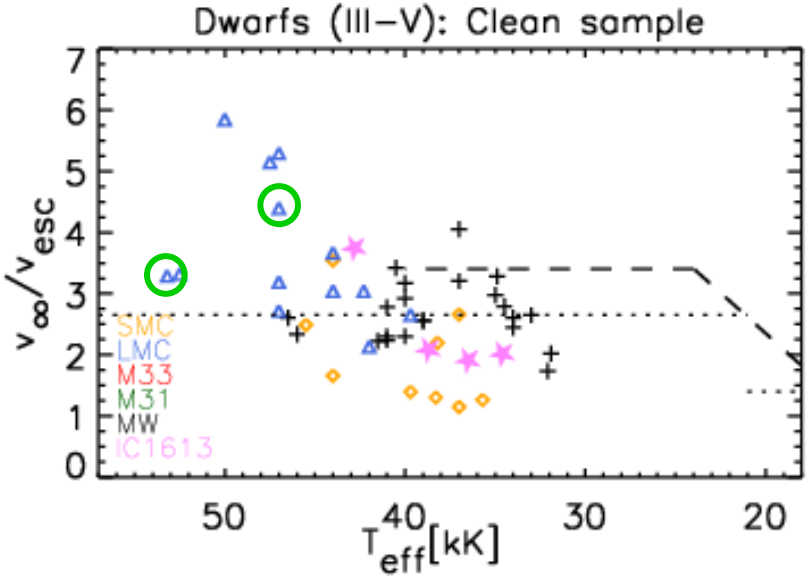
HST-COS observations

TERMINAL VELOCITIES



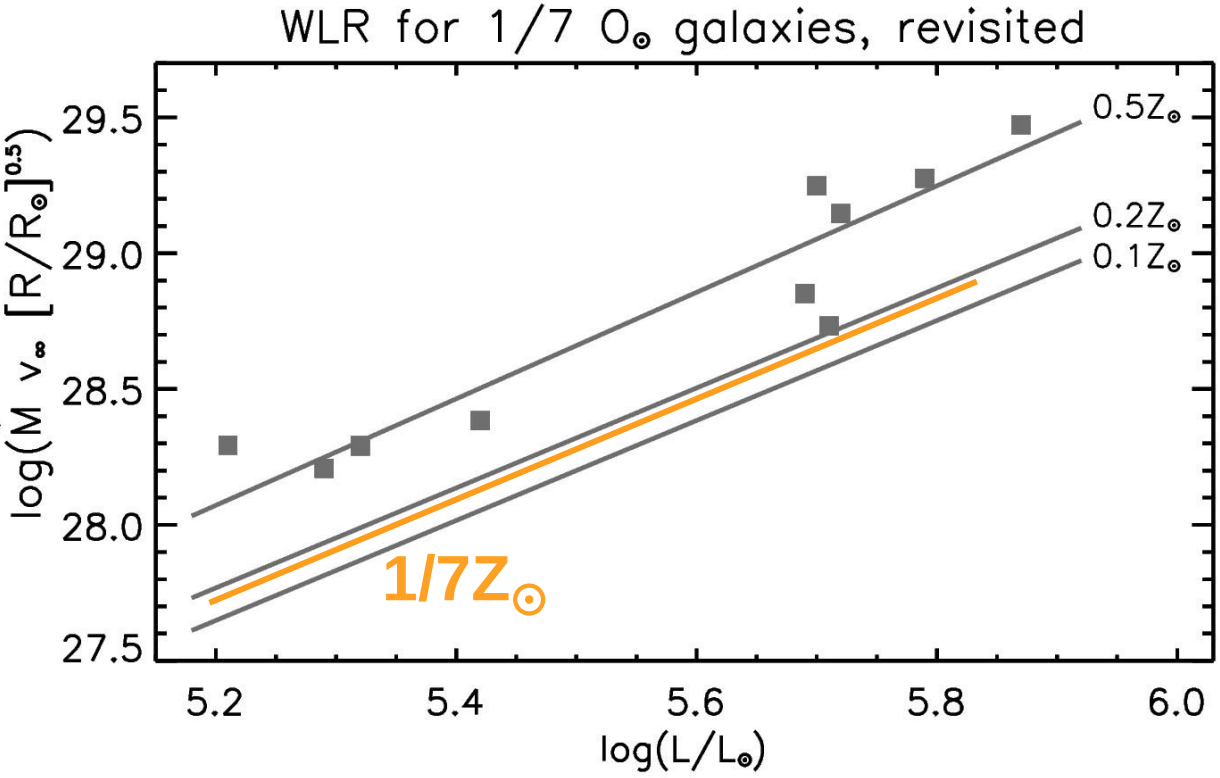






Garcia+ 2014

WIND MOMENTUM

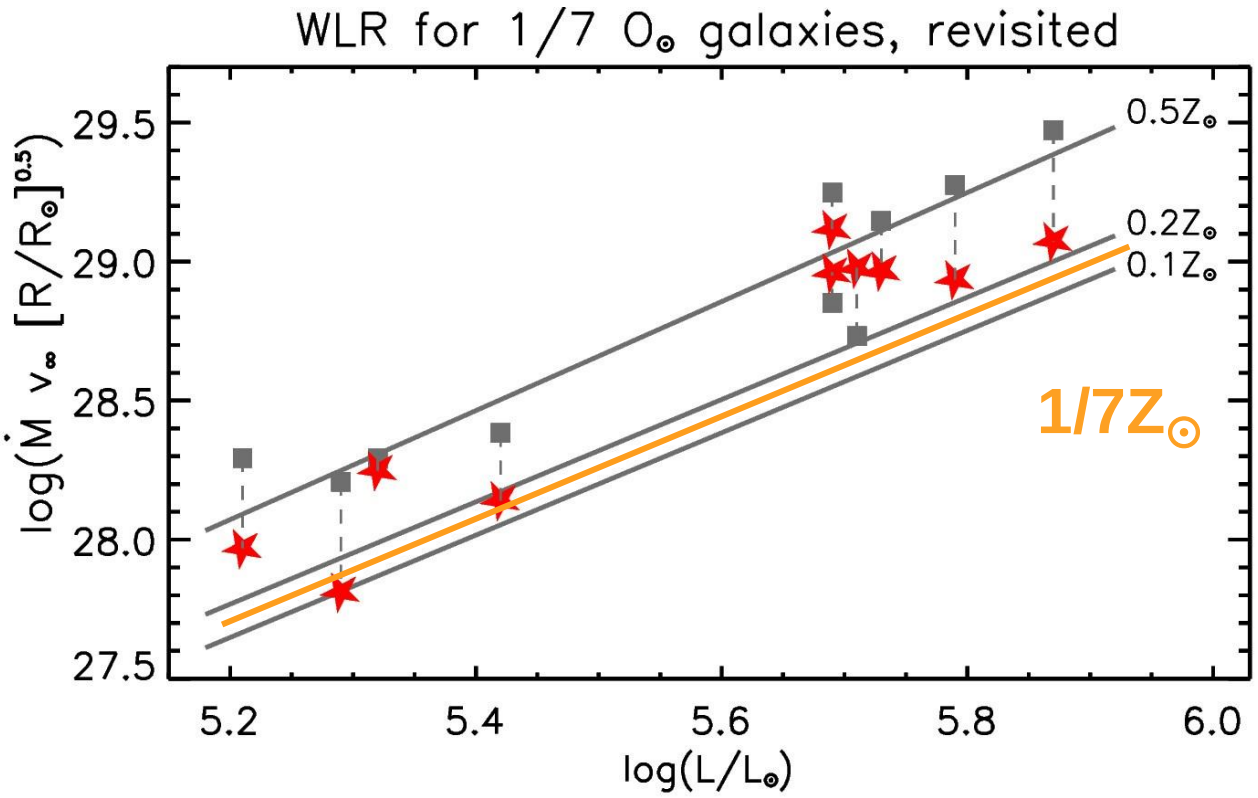


Optical data, from:

Herrero+ 2011,2012

Tramper+ 2011, 2014

WIND MOMENTUM



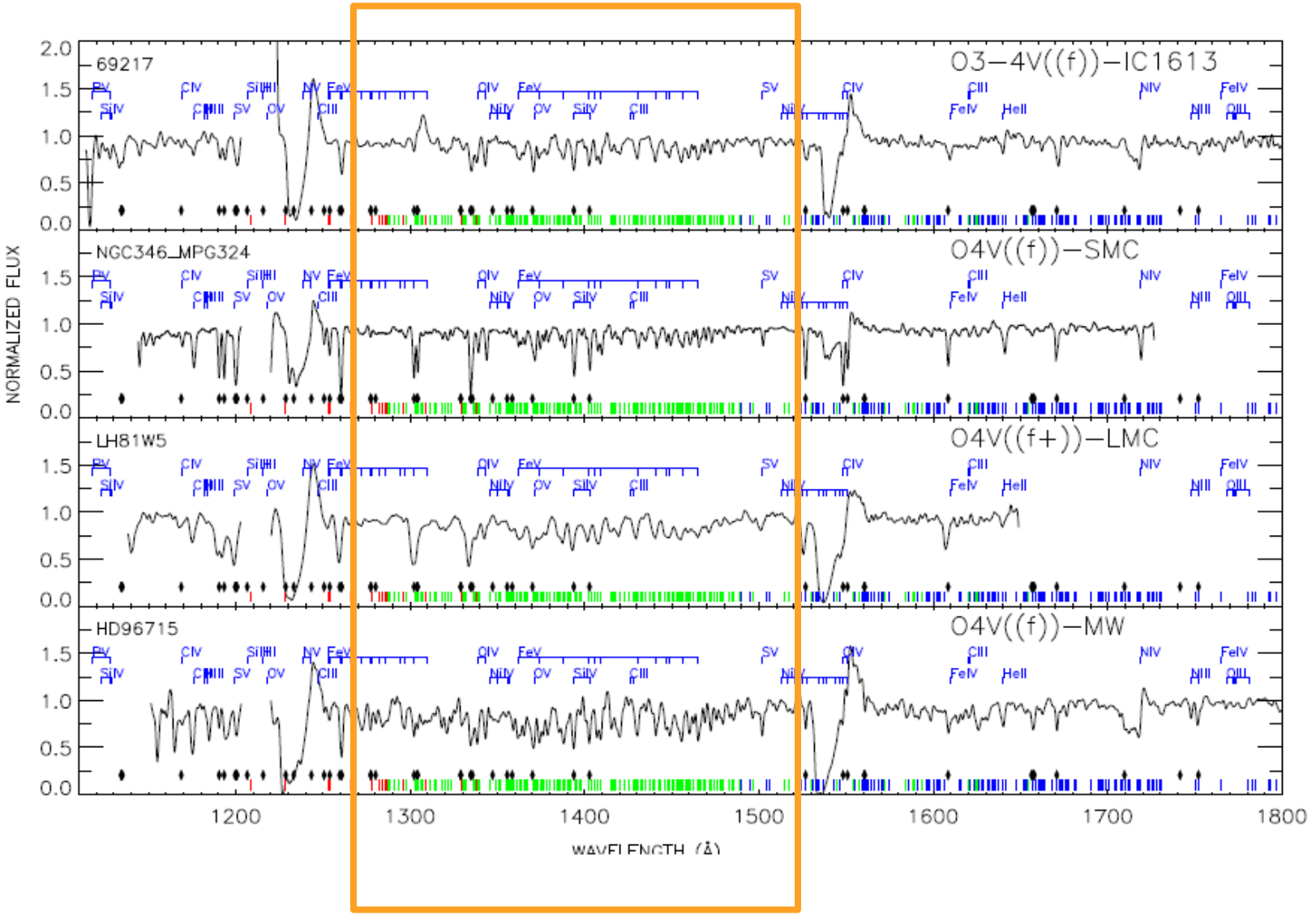
Herrero+ 2011,2012

Tramper+ 2011, 2014

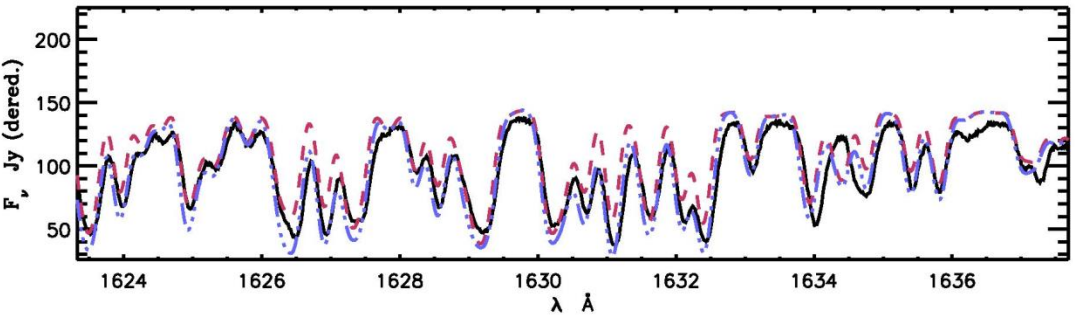
with

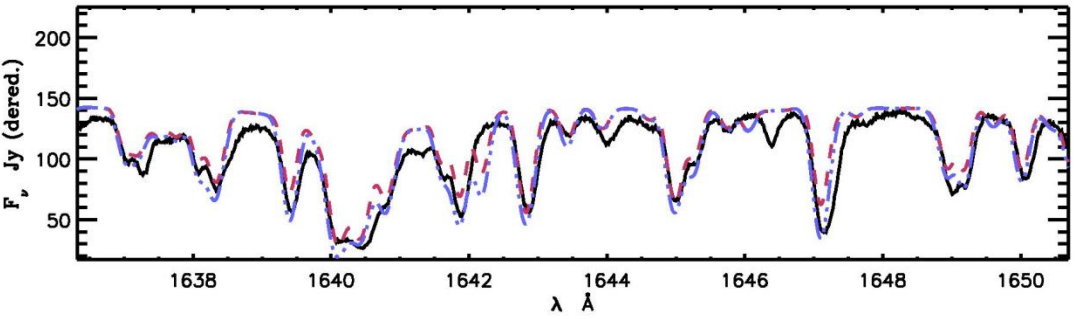
v_∞ from Garcia+2014

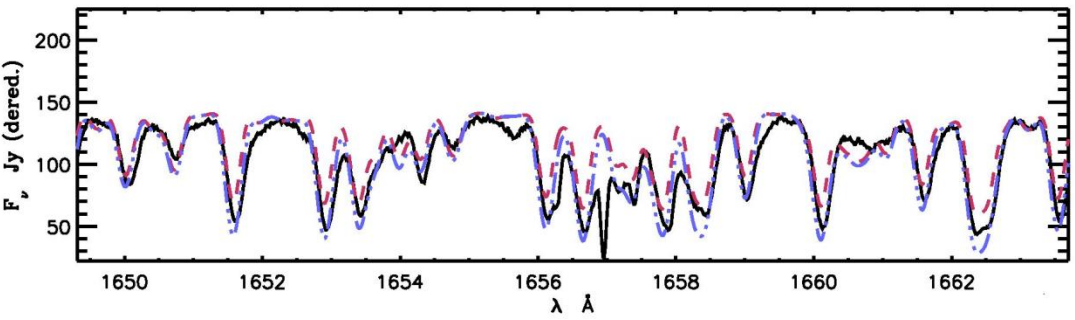
FE-CONTENT


69217
O3−4V((f))−IC1613
NGC346_MPG324
O4V((f))−SMC
LH81W5
O4V((f+))−LMC
HD96715
O4V((f))−MW
NORMALIZED FLUX
WAVELENGTH (Å)
1200
1300
1400
1500
1600
1700
1800

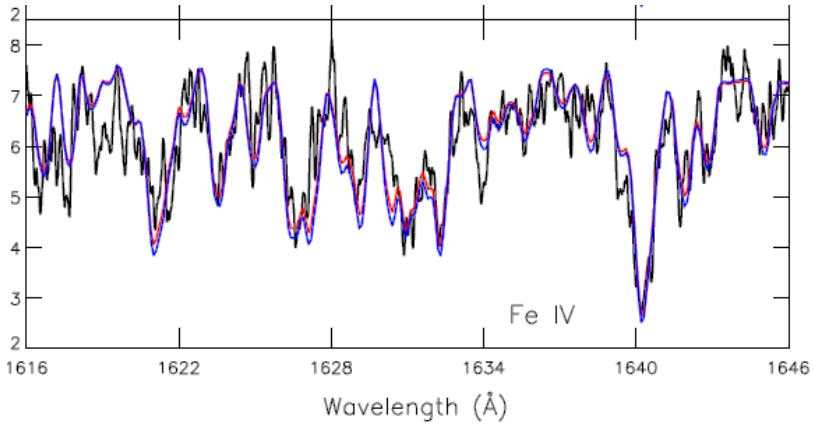
R=20000, ξ=5,10km/s







Bouret+ 2015



0.2Fe $_{\odot}$, ξ=10km/s

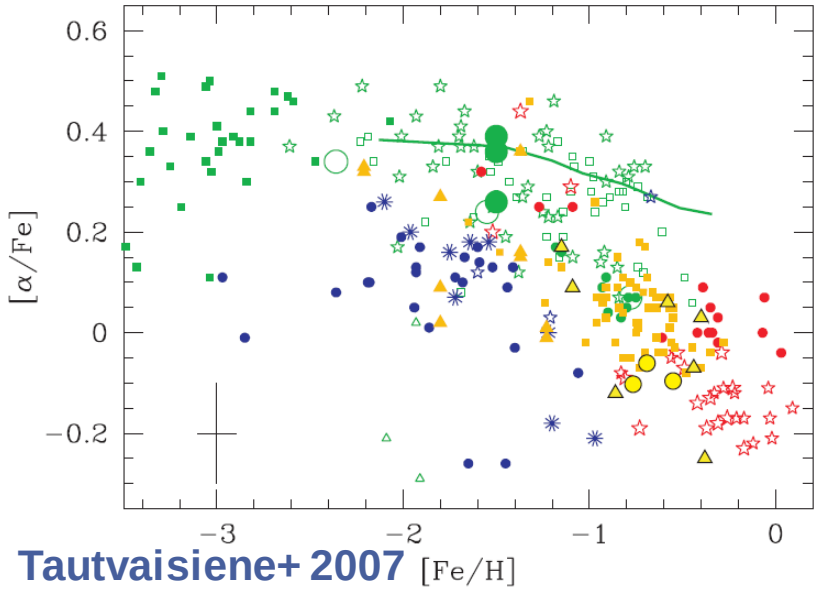
0.14Fe $_{\odot}$, ξ=13km/s

THE (TRUE?) METAL CONTENT OF GALAXIES (e.g. IC1613)

- **Iron: 1/5 $Fe_\odot$ [or slightly higher]**
  - OB stars (Garcia+ 2014; Bouret+ 2015)
  - RSG (Tautvaisiene+ 2007)

- **Oxygen: 1/7 $O_\odot$**
  - HII regions (Bresolin+ 2007)
  - B-supergiants (Bresolin+ 2007; Camacho+ in prep)

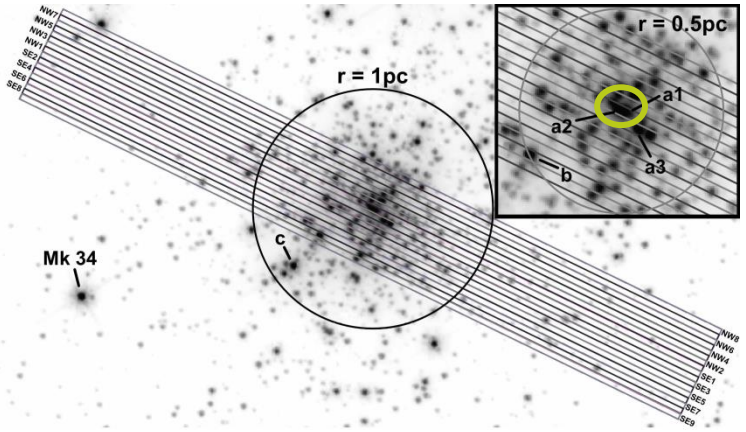
- **IC1613's [α/Fe] is subsolar**
  - [α/Fe]=-0.1 dex
  - (Tautvaisiene+ 2007)

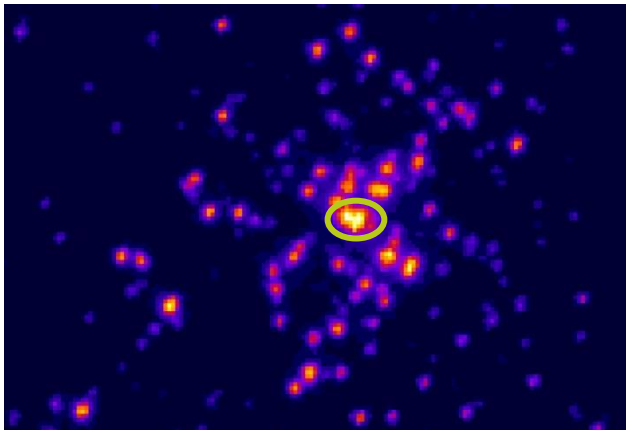


Tautvaisiene+ 2007

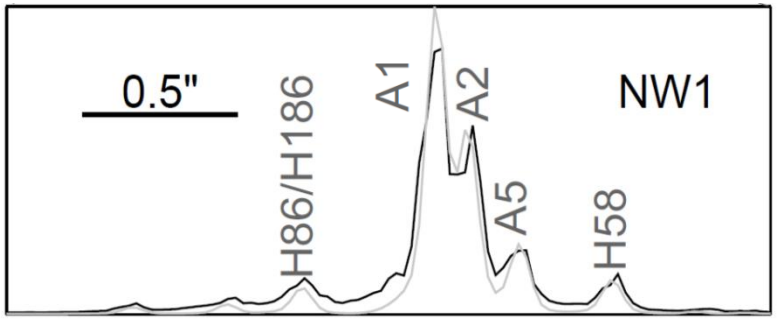
UV IMAGING:

- **Detecting and disentangling massive stars**





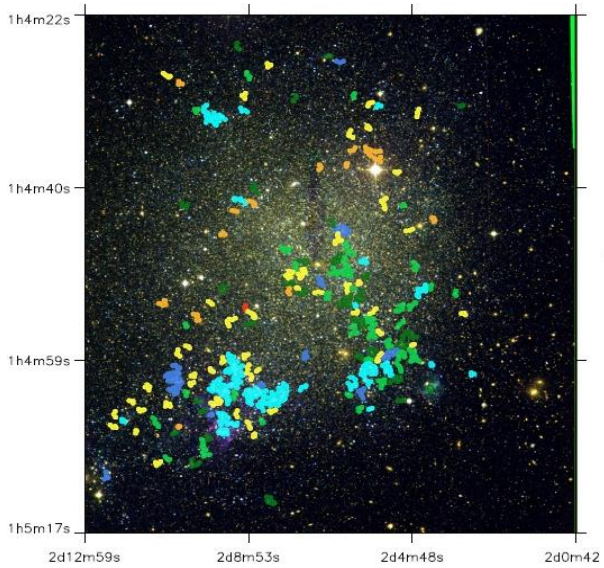
Crowther+ 2016

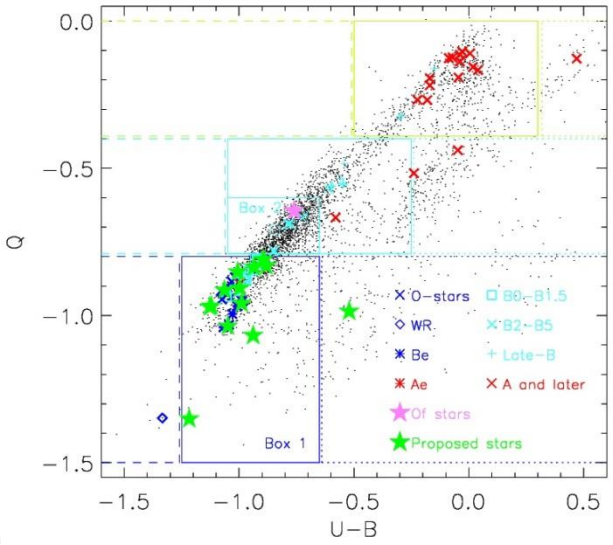


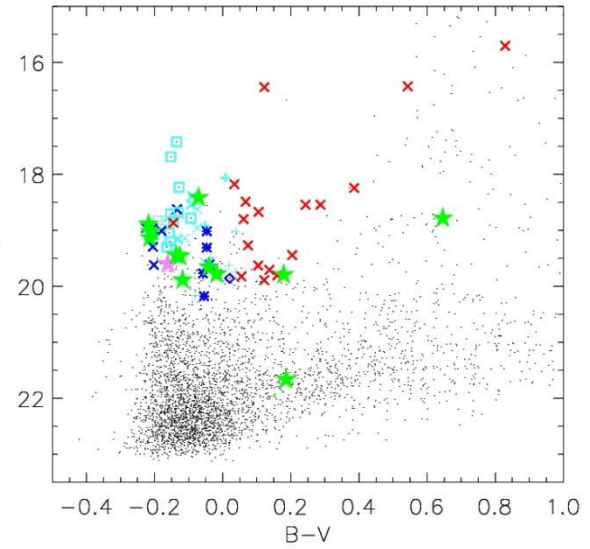
IC1613

Garcia & Herrero 2013

COLOR-BASED SEARCH OF BLUE MASSIVE STARS

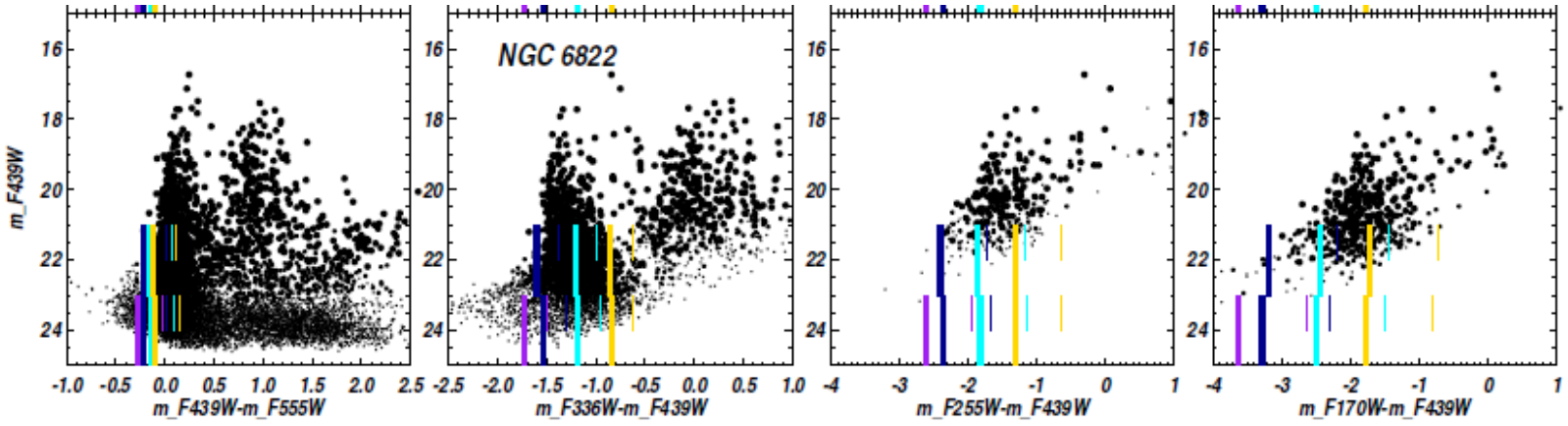




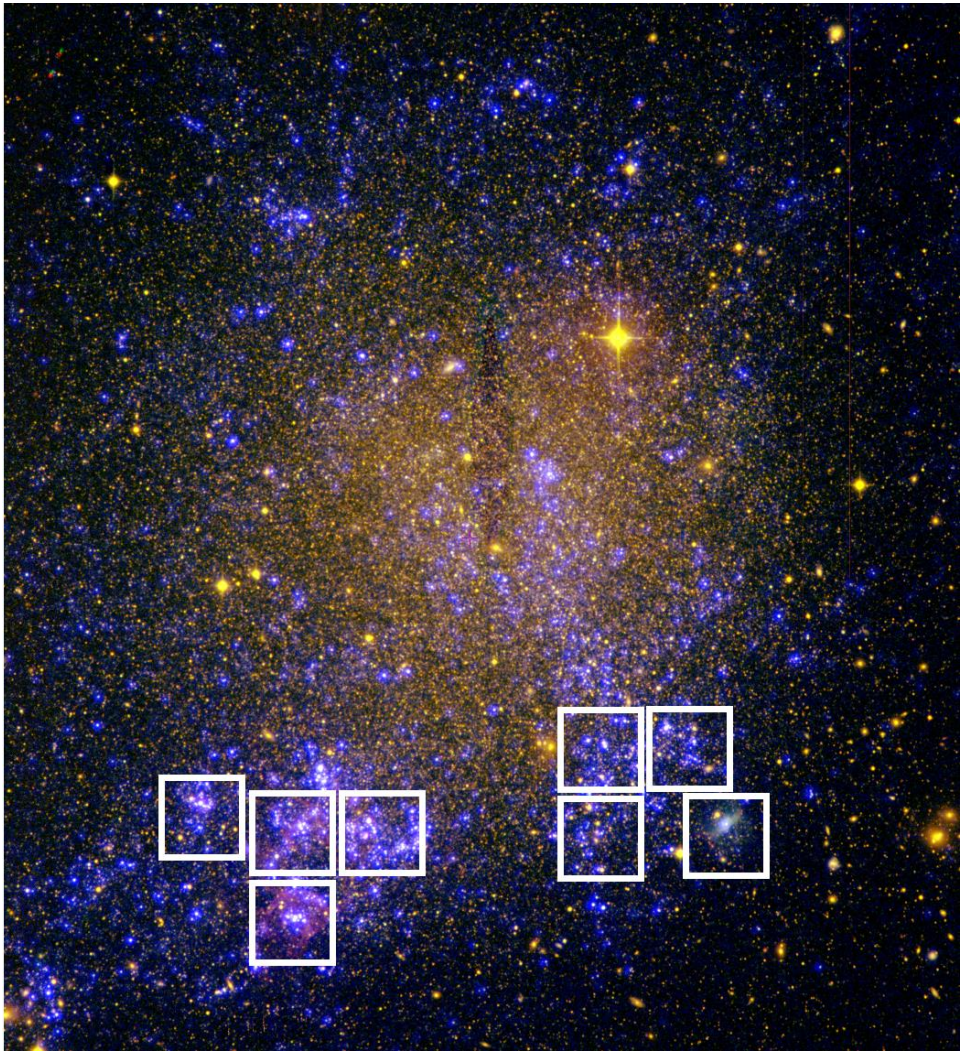


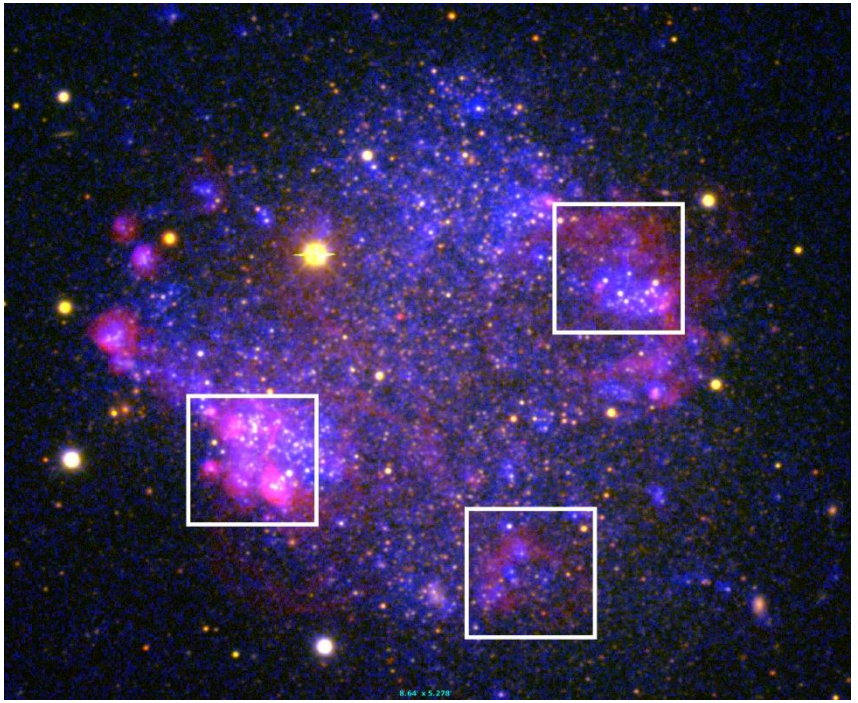
Garcia+ 2010

- **UV colors can help better pinpoint early-O and B-stars**



Bianchi+ 2012





CONCLUSIONS

- **The UV range provides unique information on massive stars, their winds and metal content.**

- **The SMC is the frontier to break in this field:**

the UV characterization of low-Z massive stars will provide crucial information on Feedback across the ages of the Universe

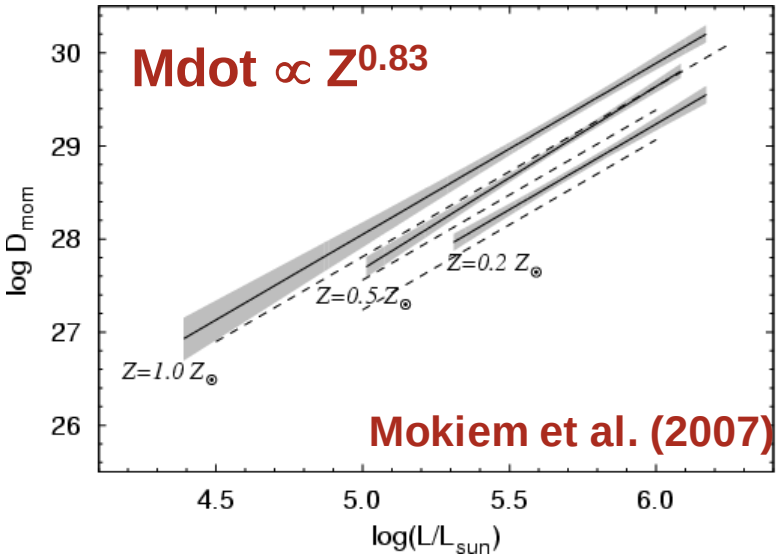
THANKS

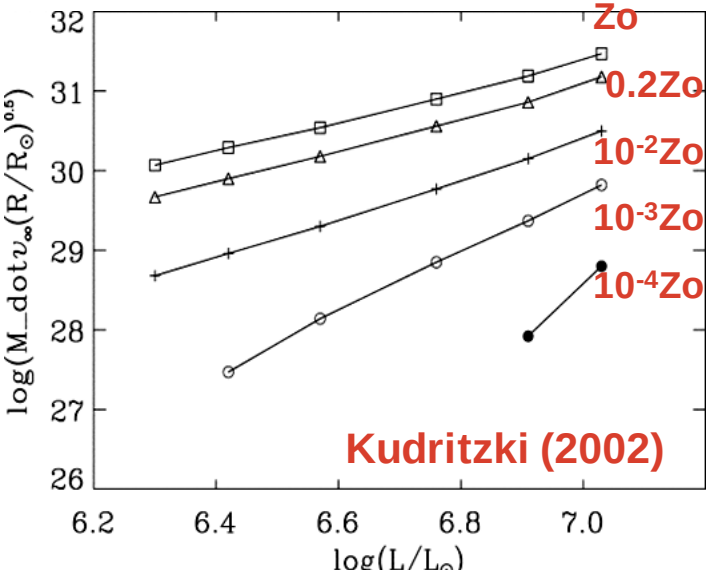
LOS VIENTOS IMPULSADOS POR RADIACIÓN DE LAS ESTRELLAS MASIVAS AZULES

- **Impulsados por scattering de fotones.**
- **Principales parámetros:**
  - Pérdida de masa ($\dot{M}$), velocidad terminal (vinf), choques (L_x -- log L_x/L_{bol})
  - En ausencia de datos UV: $v_\infty = 2.65 v_{esc}$; and then $v_\infty \propto Z^{0.13}$
  - Principal herramienta de diagnóstico: la relación entre el momento del viento y la luminosidad (WLR).

$$\log D_{mom} = \log D_0 + x \log(L/L_\odot)$$
$$D_{mom} = \dot{M}\, v_\infty (R_*/R_\odot)^{1/2}$$

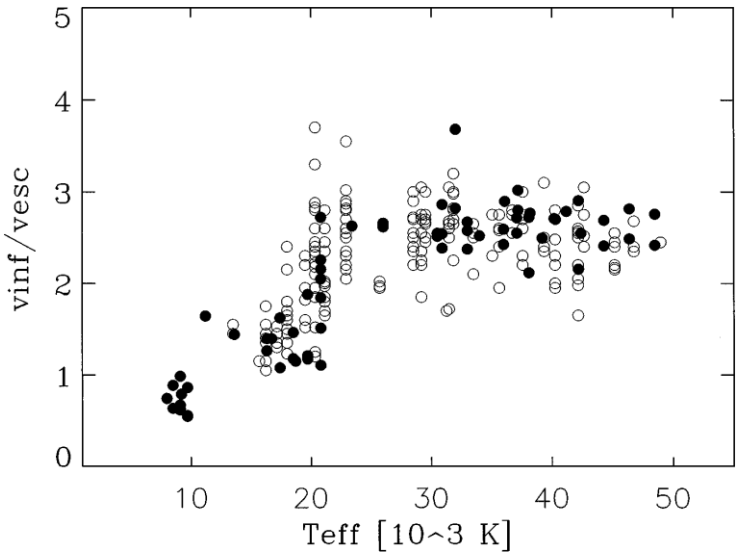
- **Dependencia con la metalicidad:**





ATACANDO EL PROBLEMA DE LOS VIENTOS DÉBILES

- **Las líneas de resonancia UV constituyen el único diagnóstico directo de la velocidad terminal v_∞**
- **v_∞ se necesita para calcular el momento del viento**
- **El análisis de espectros ópticos sólo proporciona** $Q = \dot{M}/(v_\infty \cdot R_*)^{1.5}$
- **v_∞ se suele tomar de la relación** $v_\infty = 2.65 v_{esc}$ **y despues se escala con la metalicidad** $v_\infty \propto Z^{0.13}$



Kudritzki & Puls 2000

AVISOS!!

Leitherer et al. (1992):

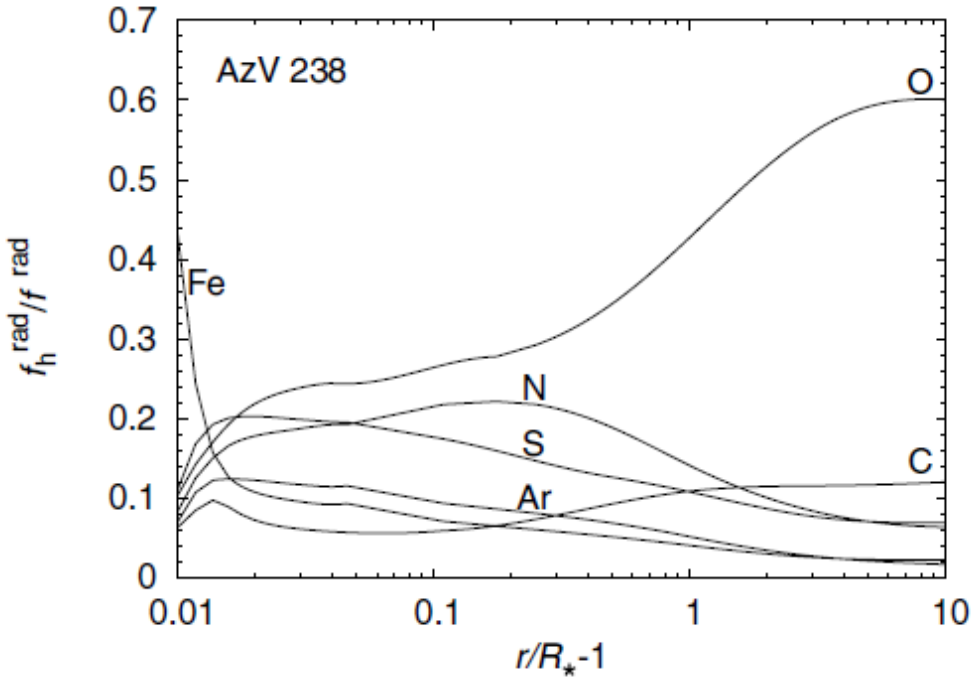
$\log(v_\infty) = 1.23 - 0.30 \log(L/L_\odot) + 0.55 \log(M/M_\odot) + 0.64 \log T_{eff} + 0.13 \log(Z/Z_\odot)$

PARTE DE LA DISPERSIÓN v_∞/v_{esc} VS T_{eff} ES ESPERABLE SEGÚN TEORÍA DE VIENTOS IMPULSADOS POR RADIACIÓN

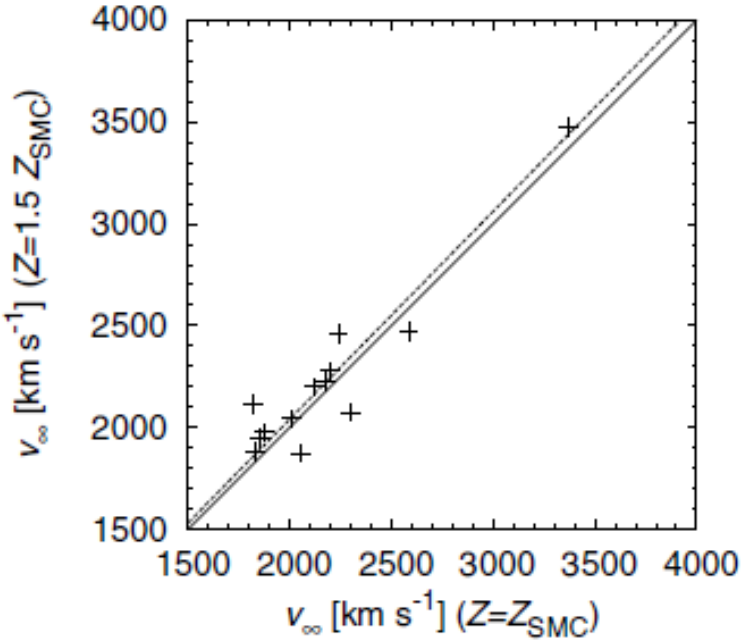
- Part of the scatter is real and expected in the context of radiation-driven wind theory

$$v_\infty = 2.25 \frac{\alpha}{1-\alpha} f_1(\alpha)\, f_2(\delta)\, f_3(v_{esc})\, v_{esc}$$

α: exponent of the power-law line-strength distribution.

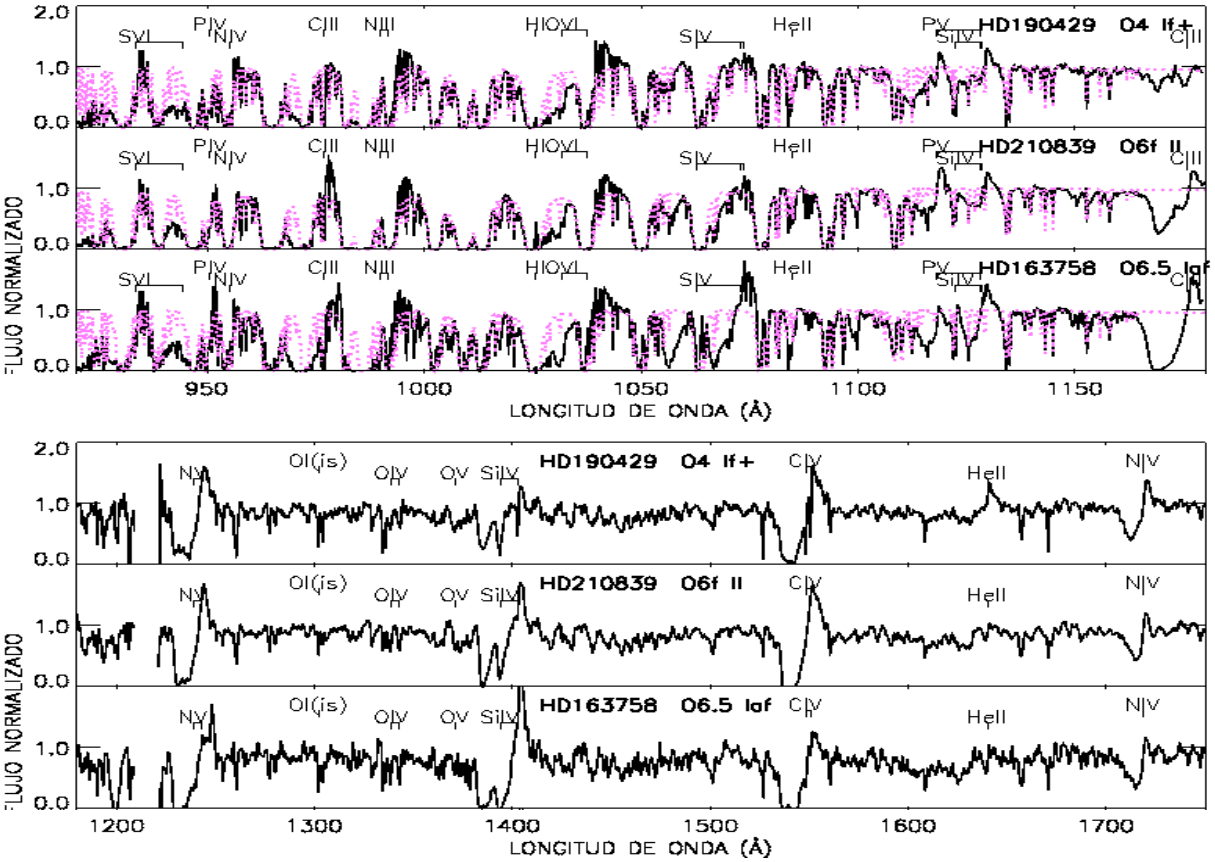


Krticka (2006)



UV SPECTROSCOPY OF MILKY WAY O-TYPE STARS

- **First analysis of FUSE and IUE observations of O-stars in the Milky Way.**

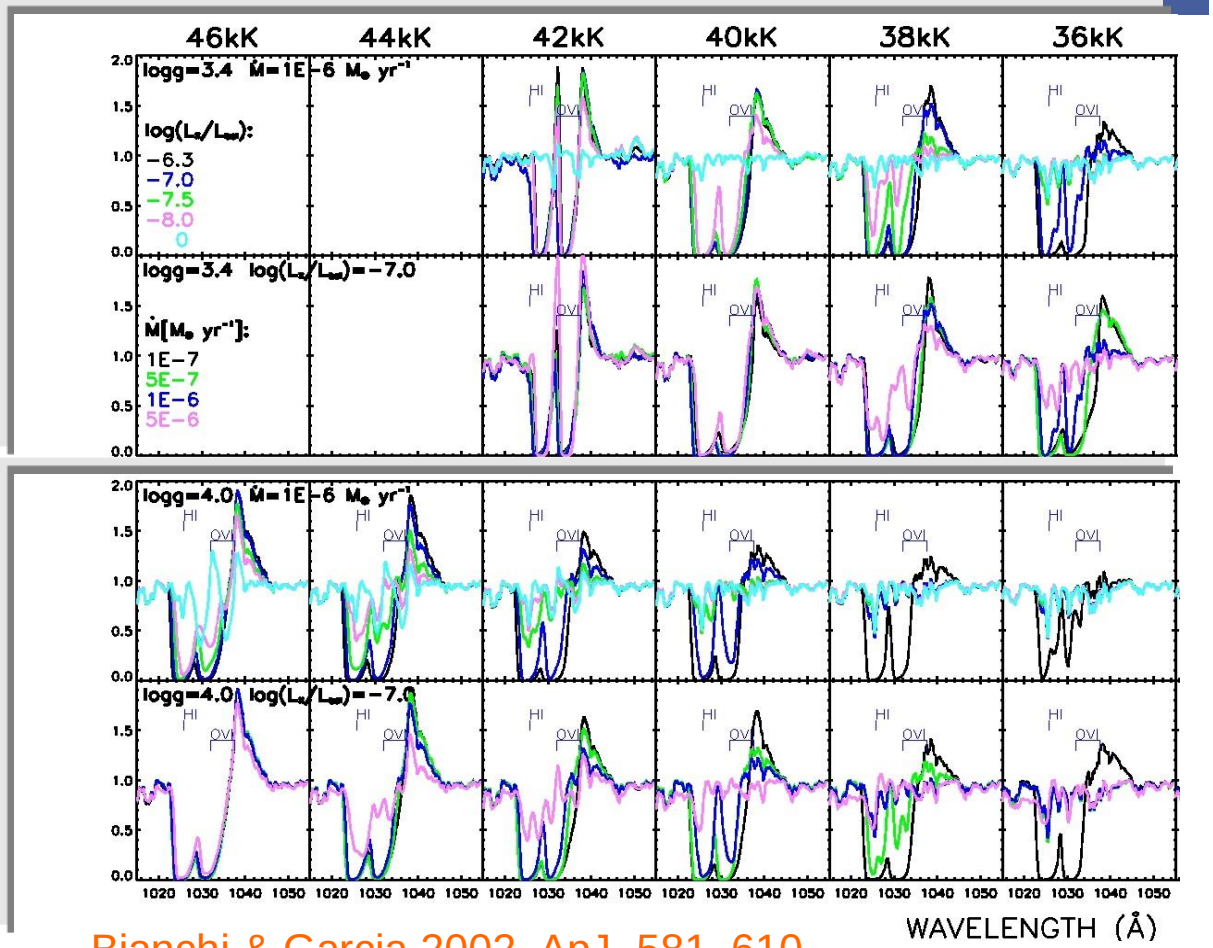


Bianchi & Garcia 2002, ApJ, 581, 610
Garcia & Bianchi 2004, ApJ, 606, 497
M. Garcia 2005, PhD dissertation
Bianchi & Garcia 2014, AdSpR, 53, 973

Impact: 89 citations,1 talk, 7 posters

UV SPECTROSCOPY OF MILKY WAY O-TYPE STARS

- Development of an extended grid of appropriate WM-basic models for analysis.



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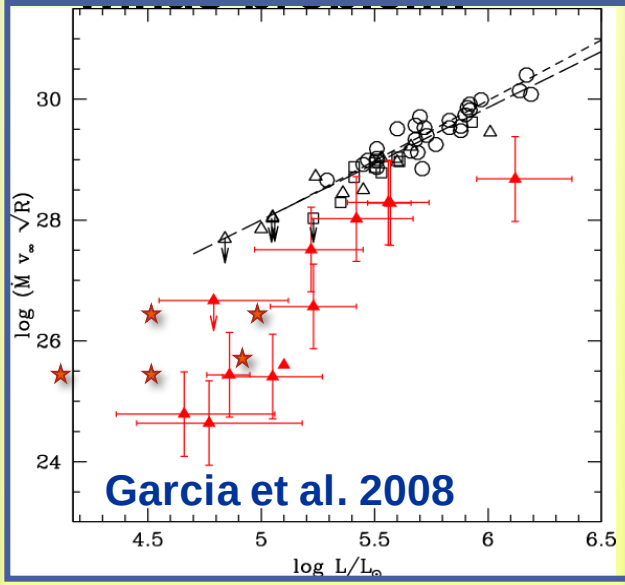
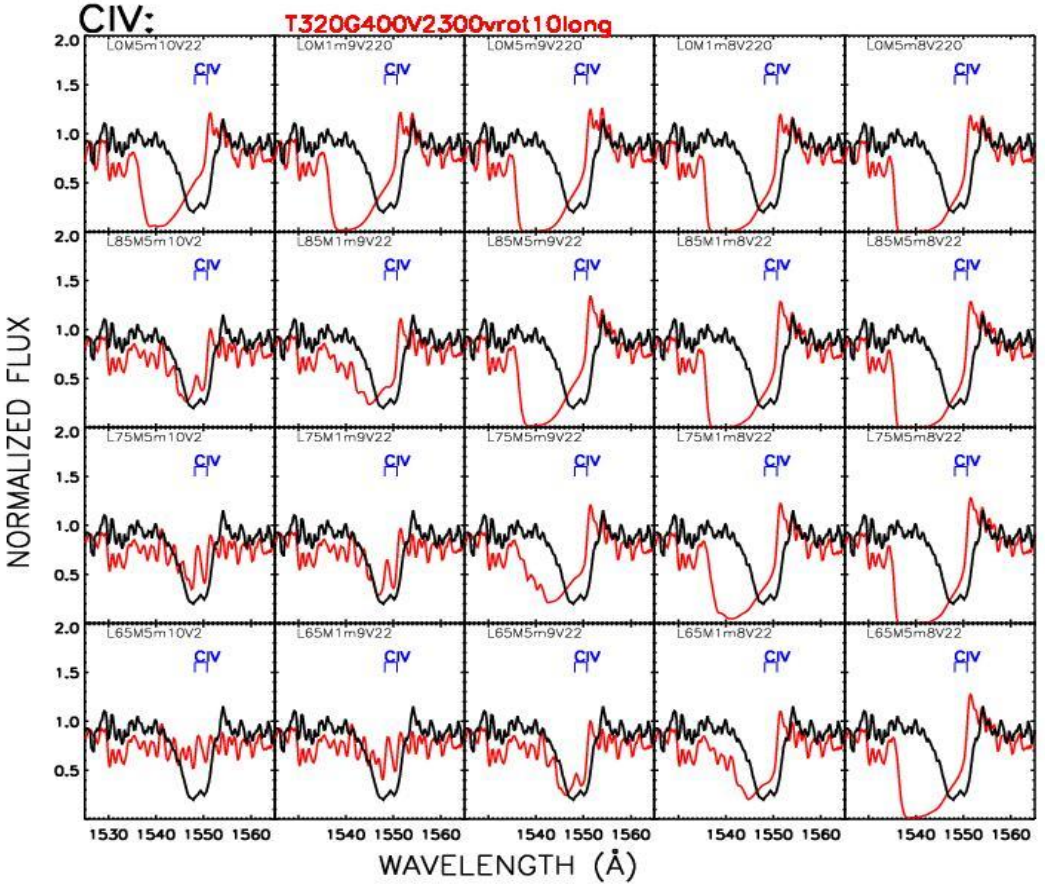
Impact: 89 citations,1 talk, 7 posters

PUBLICATIONS AND SCIENCE: WEAK WINDS, THE UV PERSPECTIVE

- **Use UV diagnostics of enhanced sensitivity to investigate the weak winds problem**



Martins et al. 2005



Garcia et al. 2011, BSRSL, 80, 144

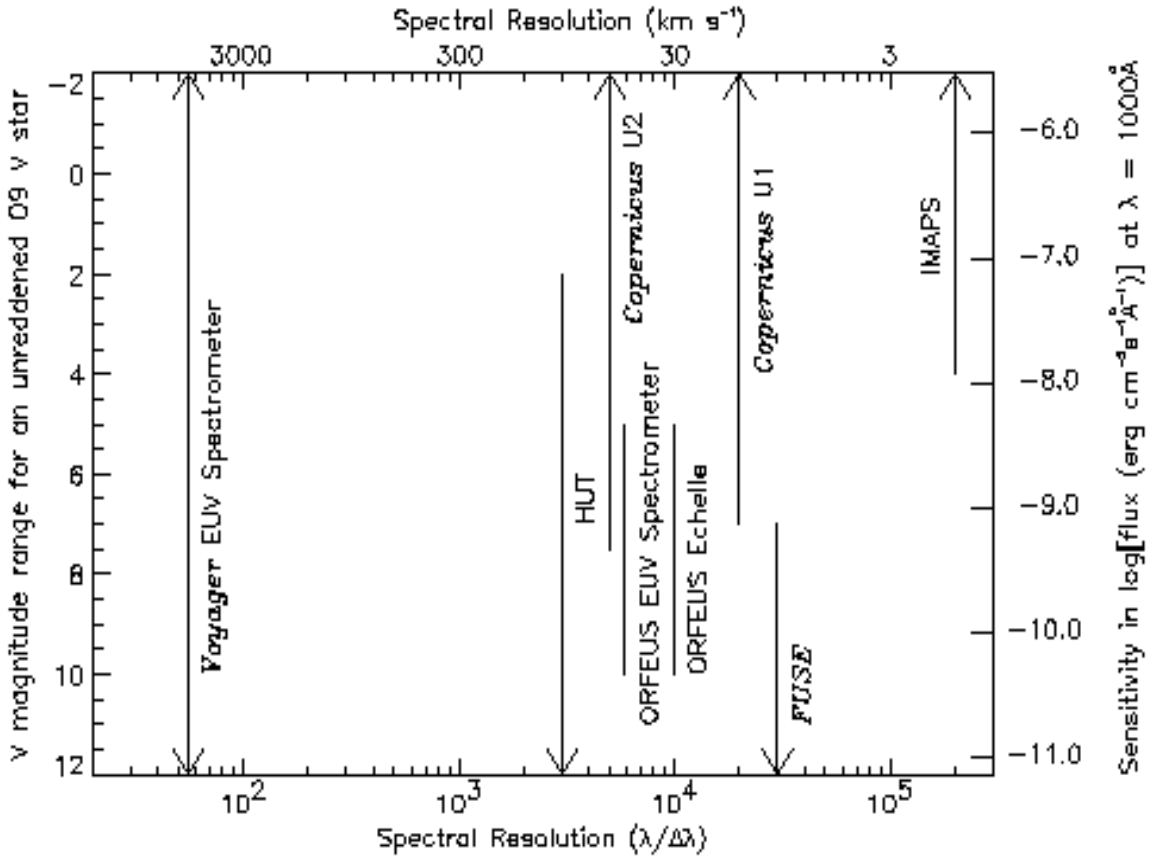
E. Keles 2011, research project

Impact: 2 citations,4 talks, 1 posters

VENTAJAS SOBRE TRABAJOS ANTERIORES EN ESTE RANGO ESPECTRAL

- **Datos de FUSE**
  - Rango espectral: 905-1187Å
  - Resolución: 🖱/◑🖱=20000
  - Área efectiva: 80 cm^2

- **Código WM-Basic**



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