Chemical composition of OB stars in the Orion star forming region

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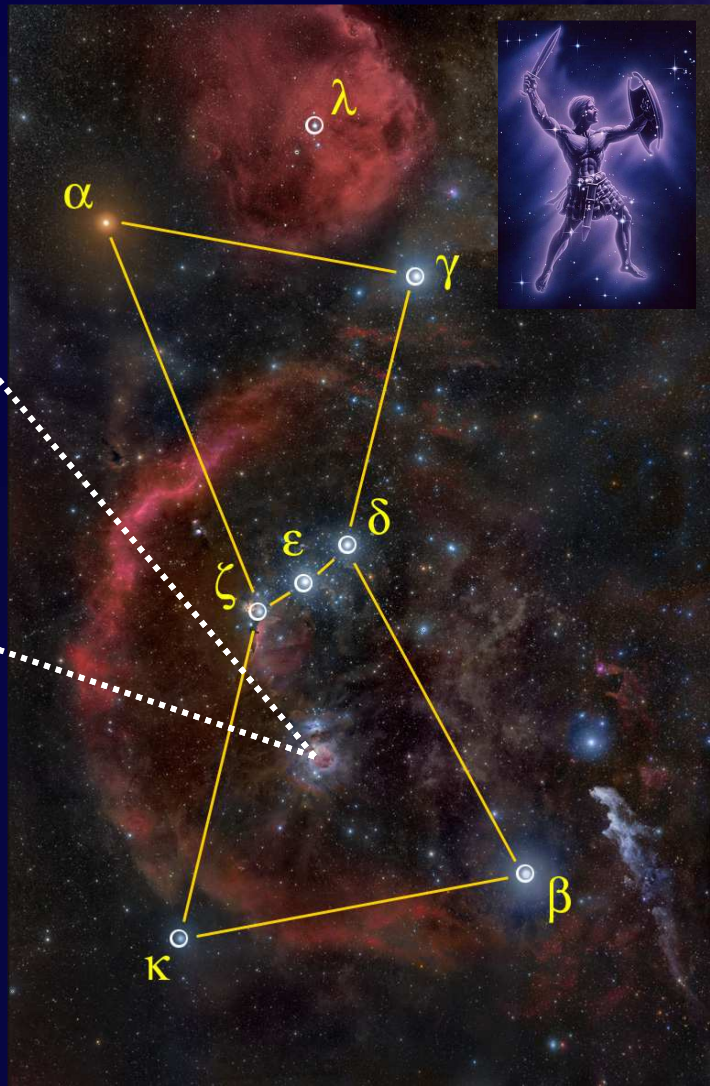
The Orion Nebula (M42)



Chemical composition of M42: Traditionally considered the standard reference for the present-day chemical composition of the solar neighbourhood.

Caveats → CEL/ORL discrepancy, icf's, dust depletion

M42, a small piece in a more general complex:

The Orion complex

The Orion complex

Orion molecular cloud (OMC) + Ori OB1 association

(One of) the most massive active star-forming regions in the solar vicinity: **The Orion star forming region**

The Orion OB1 association

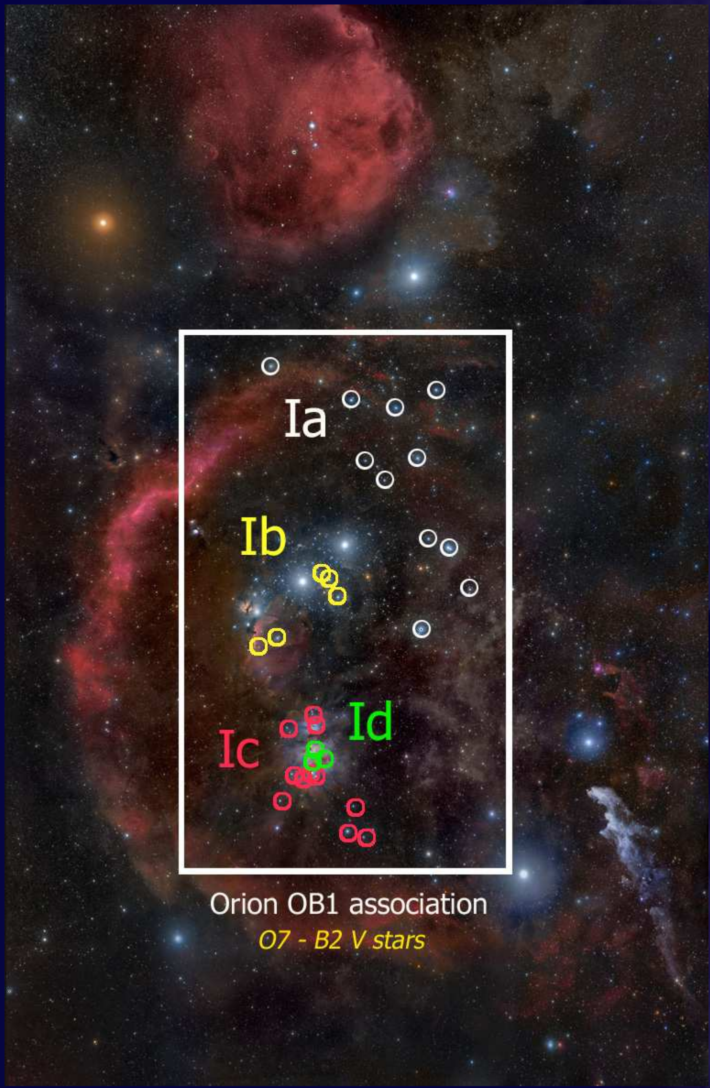
Blaauw (1964): Four subgroups with different ages and location in the sky

Brown et al. (1994):

Ia:	380(90) pc	~ 11 Myr	
Ib:	360(70) pc	~ 2 Myr	→ Horsehead nebula
Ic:	400(90) pc	~ 5 Myr	
Id:	400(50) pc	< 1 Myr	→ Orion nebula (M42)

+ observational evidence of type-II SNe events (*Goudis 1982* and references therein)

→ Example of a Galactic site with sequential/triggered star formation



Orion OB1 association

O7 - B2 V stars

The chemical composition of OB stars in the Orion star forming region

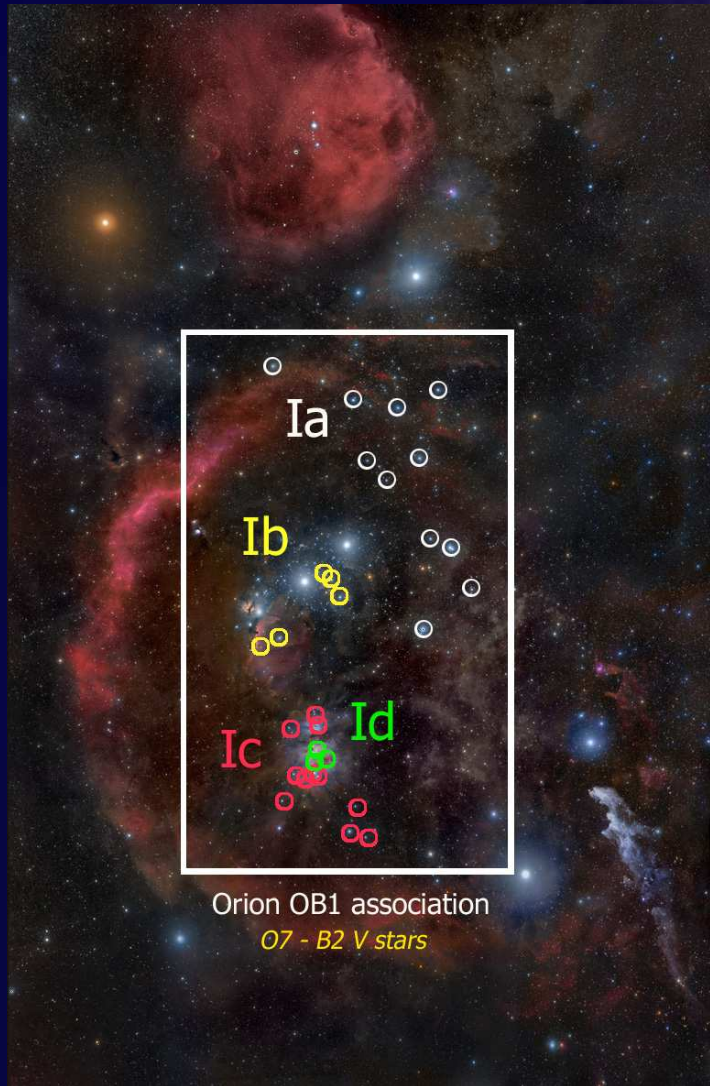
(in the context of this conference)

Photospheres of OB type main sequence stars keep the same chemical composition as the local ISM from which they were born

OB stars *(actually, low vsini early B-type):* An alternative tool to investigate the present-day chemical composition of the Galactic region where they are located

→ Direct comparison* with the abundances derived from the study of the Orion nebula (same Galactic site)

* Be aware of dust depletion and the possible enrichment of the youngest stars by type-II SNe ejecta (O, Si ...) in a sequential star formation scenario



Orion OB1 association

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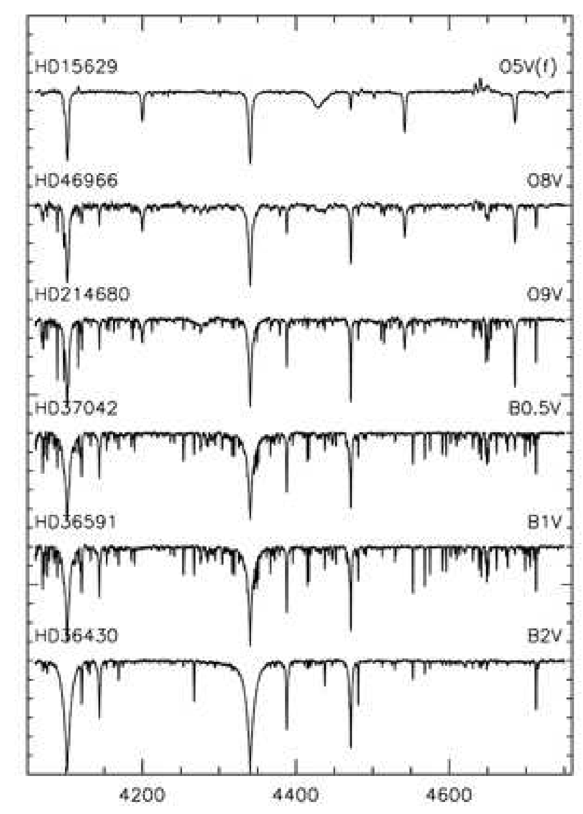
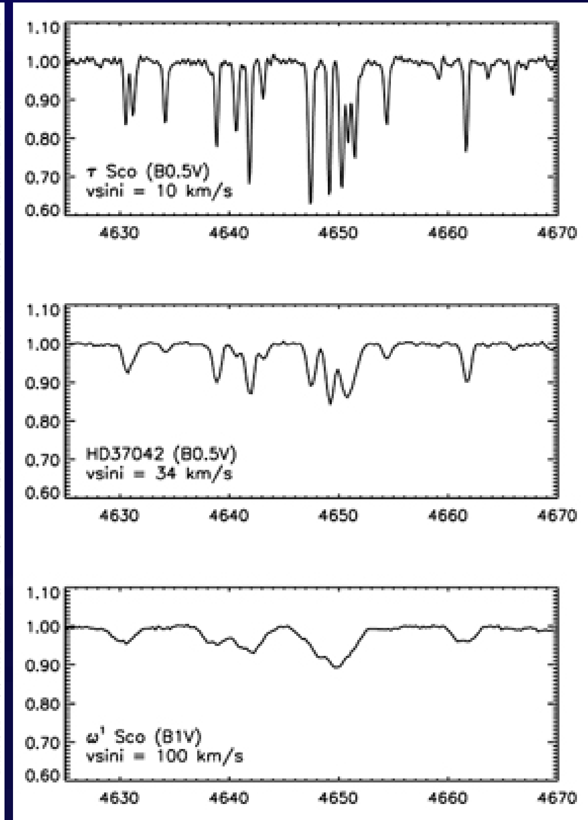
The chemical composition of OB stars in the Orion star forming region

Looking for good candidates ...





Best candidates:

Main sequence
early-B stars (B0 – B2)
with low vsini (< 50 km/s)

Diagnostic lines

C III + C II
(N III) + N II
O II (+ O I)
Ne I + Ne II
Ar II
S II + S III
Si IV + Si III + Si II
Mg II
Fe II + Fe III
H I + He I + He II

B1 V → B1.5 V
O9 V → B0.5 V   B1.5 V → B2 V
SpT > O9 V   SpT < B2 V

vsini < 30 km/s ←← Ideal !!
30 < vsini < 60 km/s ←← Still good !
vsini > 60 km/s ←← More difficult

The chemical composition of early B MS stars in the Orion star forming region

(in a more general context)

O'Dell (yesterday): One must understand the best example of a class of objects before generalizing about more distant objects

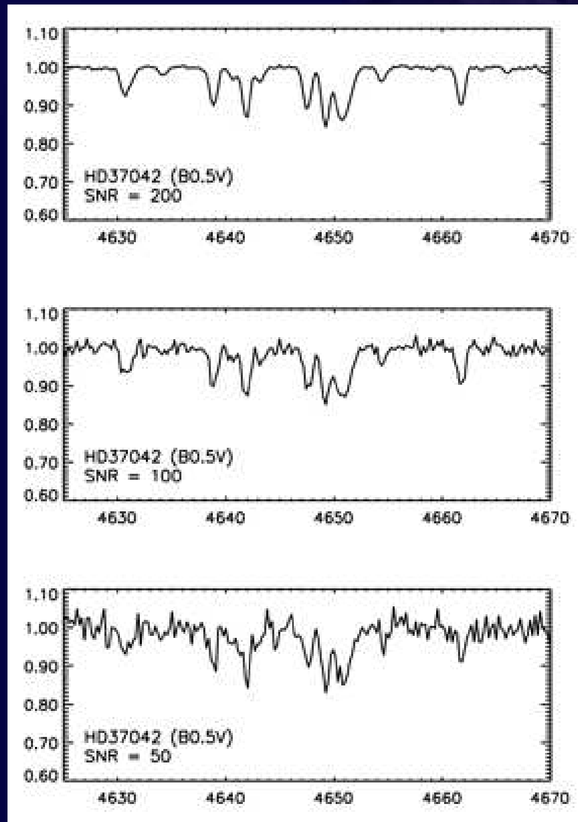
Ori OB1 contains a large number of bright, low vsini, early B-type stars (covering the full range B0-B2)

→ we can test our codes, methods, and atomic data with a set of high quality spectra

+ identification of problematic/best diagnostic lines

+ identification of possible biases and systematics

→ a reference for abundance studies of more distant stars (and/or larger vsini)



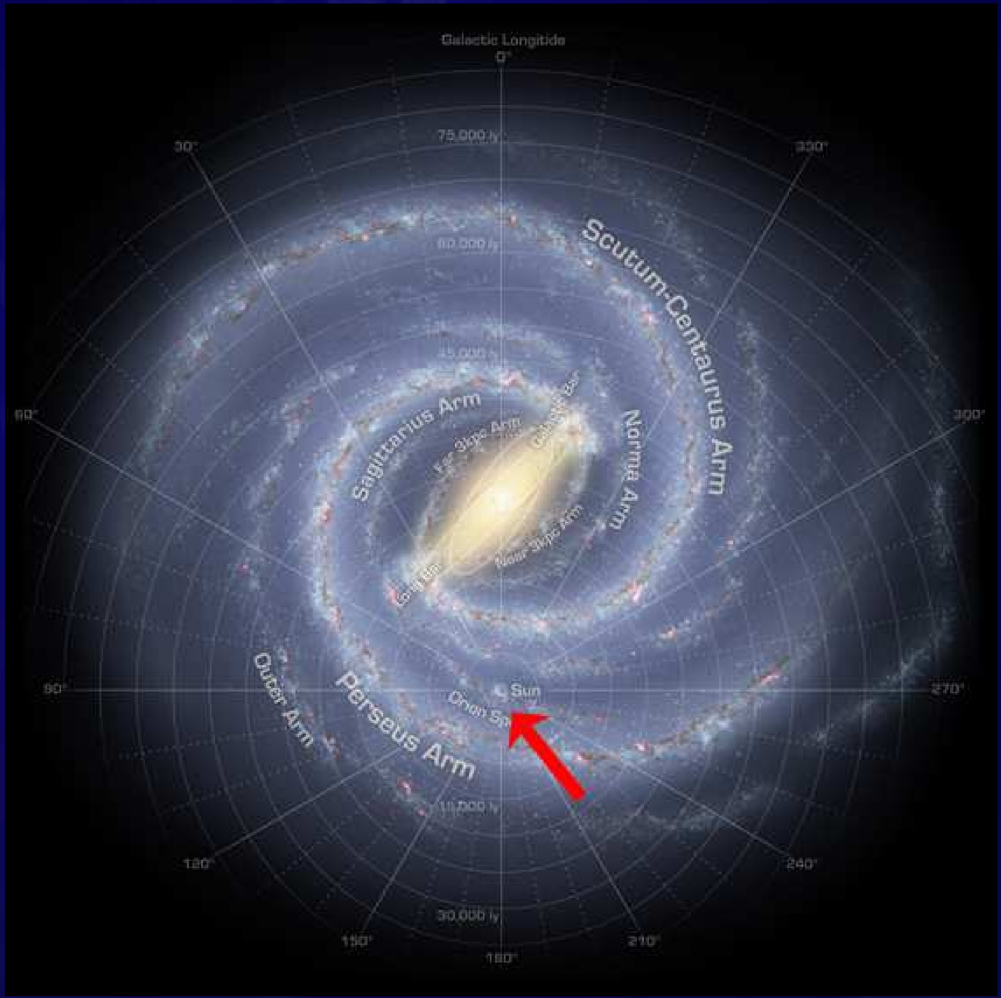
Ideal !! → → SNR > 150

Still good ! → → 100 < SNR < 150 km/s

More difficult → → SNR < 100 km/s

The chemical composition of early B MS stars in the Orion star forming region

(in a more general context)



Put more constraints to the present-day chemical composition* of the solar vicinity, including elements which cannot be easily studied from HII regions (e.g. Si, Mg)

* No dust depletion !!

Chemical abundance studies of early-B stars in Orion OB1

A quick summary of what can be found in the literature

	Cunha & Lambert (1994)		*Cunha et al. (2006)* *Lanz et al. (2008)* *Daflon et al. (2009)*	*Simón-Díaz (2010)*	*Nieva & Simón-Diaz (2011)*
	LTE	NLTE			
O	8.73 ± 0.13	8.72 ± 0.13		8.73 ± 0.04	8.77 ± 0.03
Si	7.36 ± 0.14	7.14 ± 0.13		7.51 ± 0.03	7.50 ± 0.06
C	8.35 ± 0.06	8.40 ± 0.11			8.35 ± 0.03
N	7.79 ± 0.11	7.76 ± 0.13			7.82 ± 0.07
Fe	7.47 ± 0.10				7.52 ± 0.02
Mg					7.57 ± 0.06
Ne			8.11 ± 0.04		8.09 ± 0.05
Ar			6.66 ± 0.06		
S			7.15 ± 0.05		
	18 stars (B0-B2) : Ia,b,c,d		11 stars (B1-B1.5): Ia,b,c	13 stars (B0–B2): Ia,b,c,d	

- Different codes, different strategies (will talk about this in a few minutes ...)
- Not many differences between "old" and "new" mean values (except for Si)
- The associated dispersions have drastically decresed in many cases

The chemical composition of early-B type stars in Ori OB1 *(Cunha & Lambert 1994)*

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CHEMICAL EVOLUTION OF THE ORION ASSOCIATION. II. THE CARBON, NITROGEN, OXYGEN, SILICON, AND IRON ABUNDANCES OF MAIN-SEQUENCE B STARS

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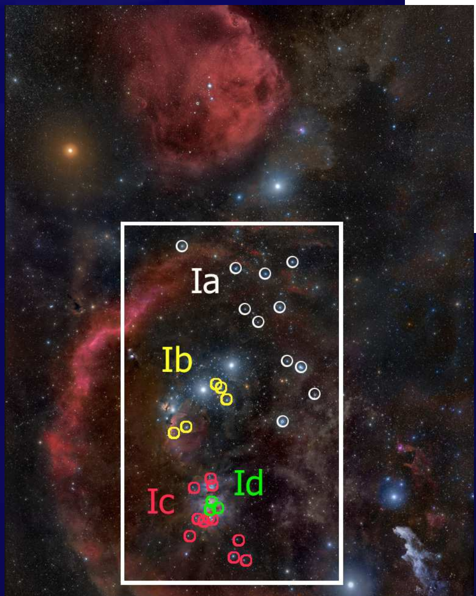
Received 1993 September 17; accepted 1993 November 3

ABSTRACT

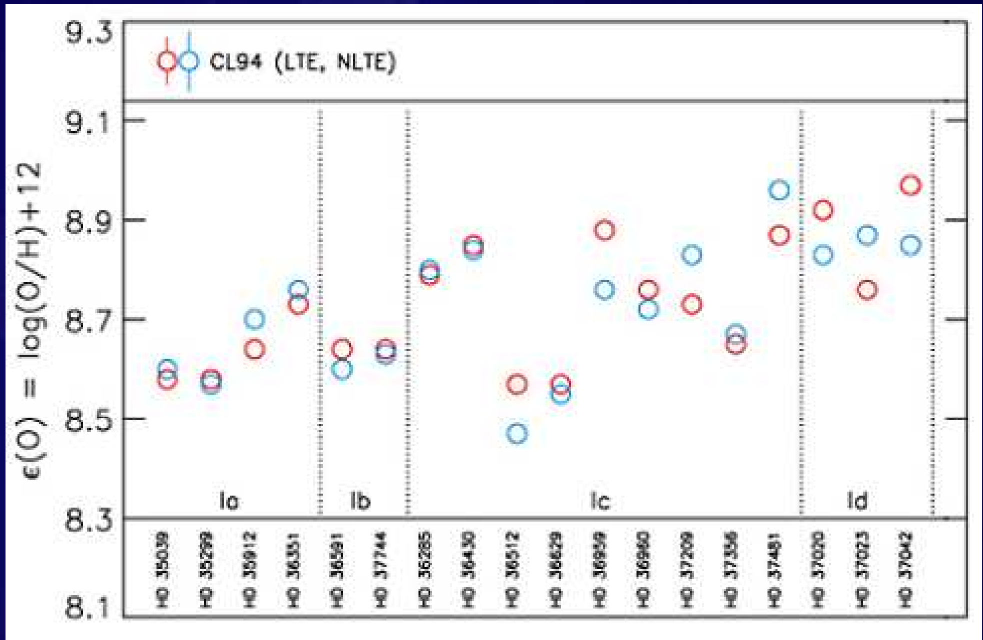
Carbon, nitrogen, oxygen, and silicon abundances are presented from LTE and non-LTE analyses of C II, N II, and Si III lines in the spectra of 18 main-sequence B stars from the four subgroups comprising the Orion association. Iron LTE abundances from Fe III lines are also presented. The C, N, and Fe abundances show no significant variations across the subgroups, but the O and Si abundances are found to be higher for some of the youngest stars that are collocated on the sky and at a common distance. The O and Si abundances are correlated. Although such a correlation may in part reflect measurement errors, it is suggested that the enrichment of young stars in O and Si arose because they were formed from regions of the molecular cloud enriched with the ejecta of Type II supernovae, which are predicted to be rich in O and Si but not in C and N. With the exception of one star, we see no evidence for CN-cycled material on the stars' surfaces. The stellar abundances agree, within the expected uncertainties, with published nebular analyses that show Orion to be slightly underabundant in C, N, and O relative to the Sun.

Subject headings: open clusters and associations: individual (Orion I) — stars: abundances — stars: early-type

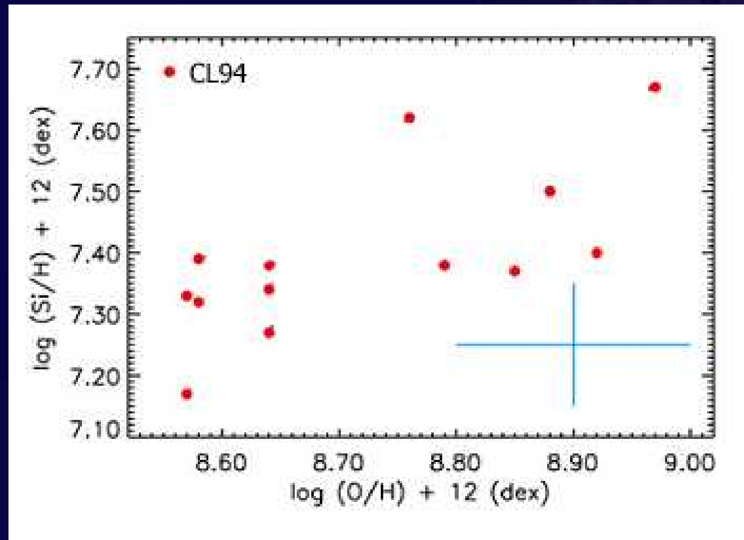


Orion OB1 association
O7 - B2 V stars

The chemical composition of early-B type stars in Ori OB1 *(Cunha & Lambert 1994)*



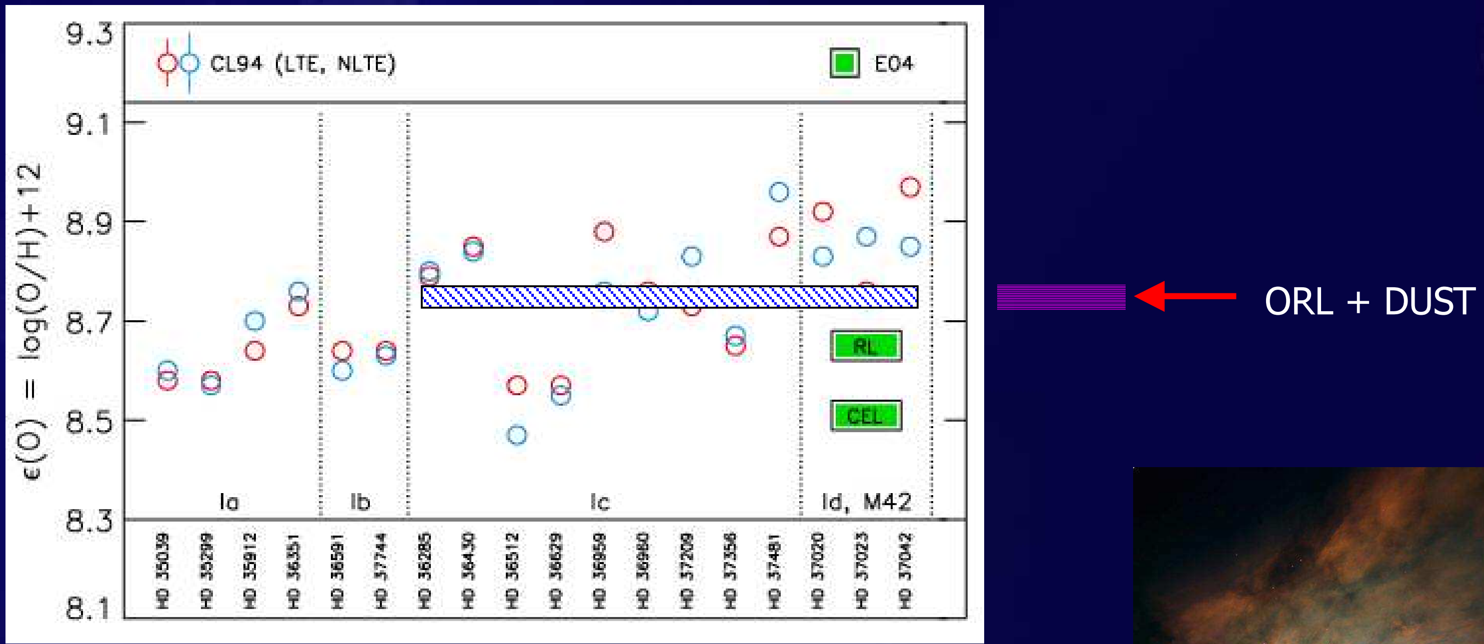
The higher values of the O abundances are found for stars in the youngest groups (Id and some Ic)

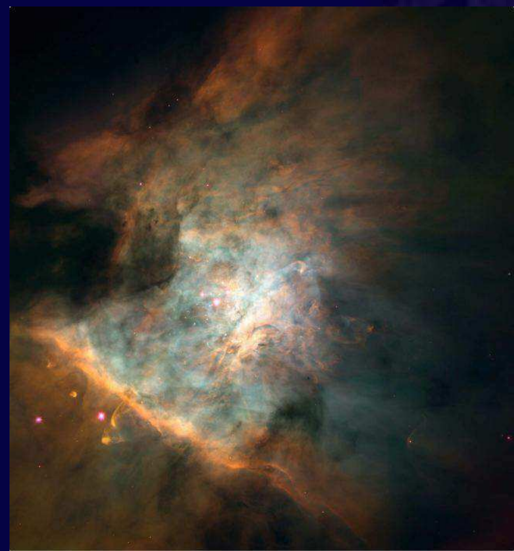


O and Si abundances are correlated

➡ Coherent with a scenario of induced star formation in which the new generation of stars are formed from insterstellar material contaminated by type-II SN ejecta (O, Si, ...)

(Comparison with the O abundance content in the Orion nebula)

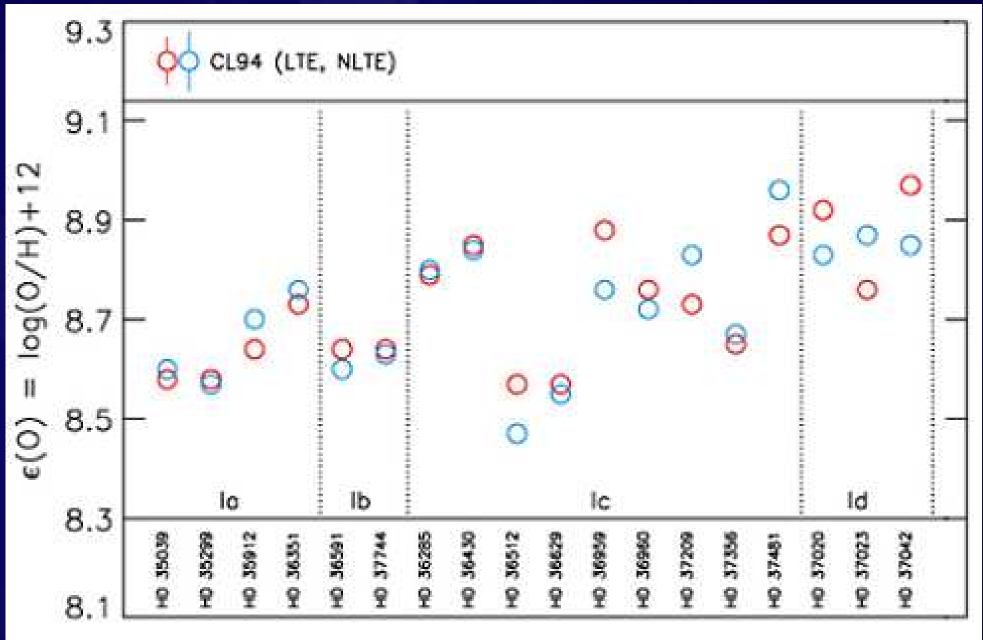


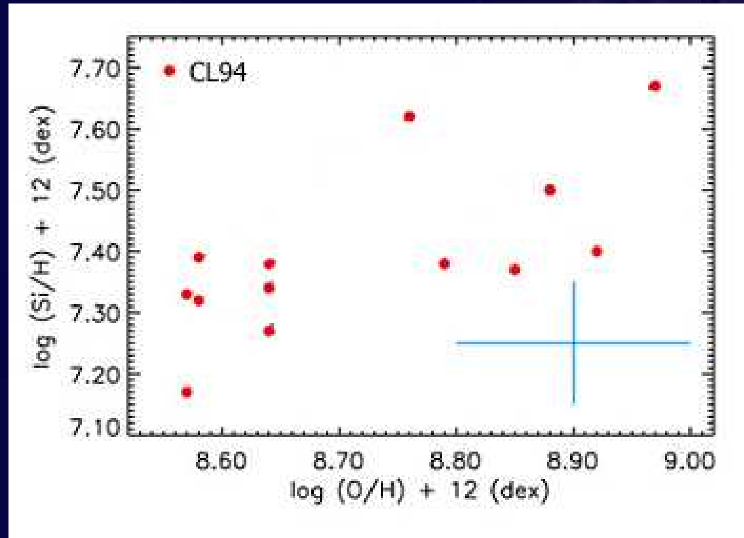


Oxygen abundance in M42 *(Esteban et al. 2004)*

- Preferred diagnostic lines: ORL
- O depleted on to dust grains by a factor of 0.08 dex *(Esteban et al. 1998)*

The chemical composition of early-B type stars in Ori OB1 *(Cunha & Lambert 1994)*





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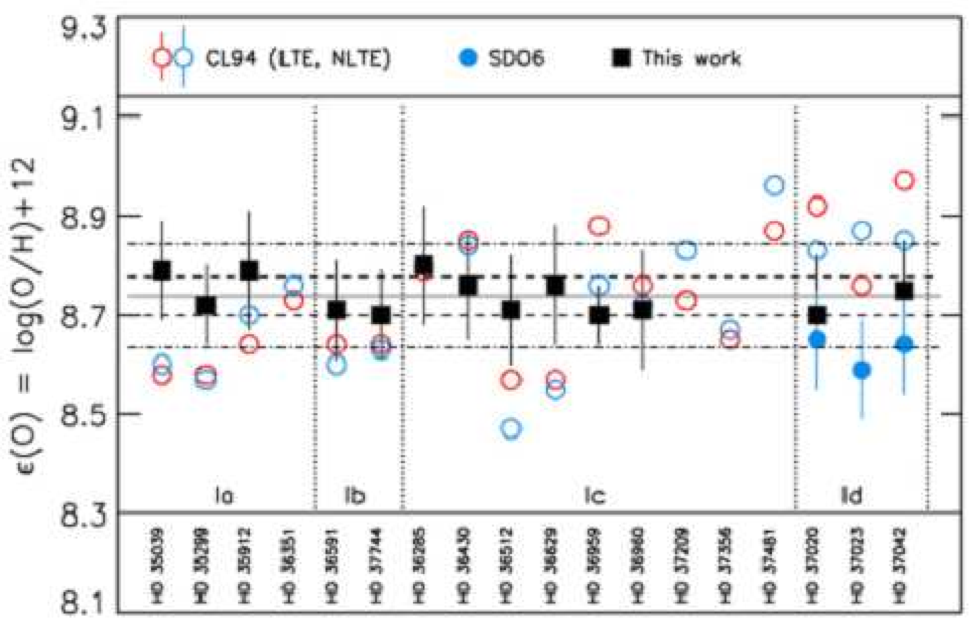
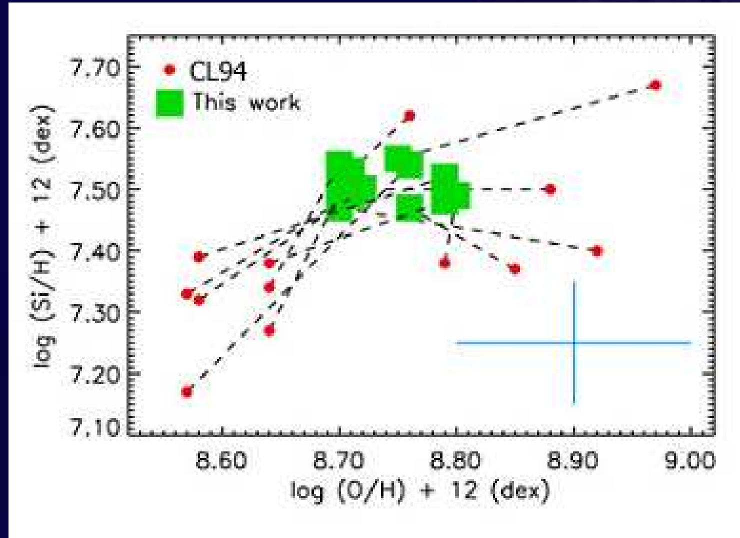
O and Si abundances are correlated

Coherent with a scenario of induced star formation in which the new generation of stars are formed from insterstellar material contaminated by type-II SN ejecta (O, Si, ...)

The chemical composition of early-B type stars in Ori OB1 *(Simón-Díaz 2010)*

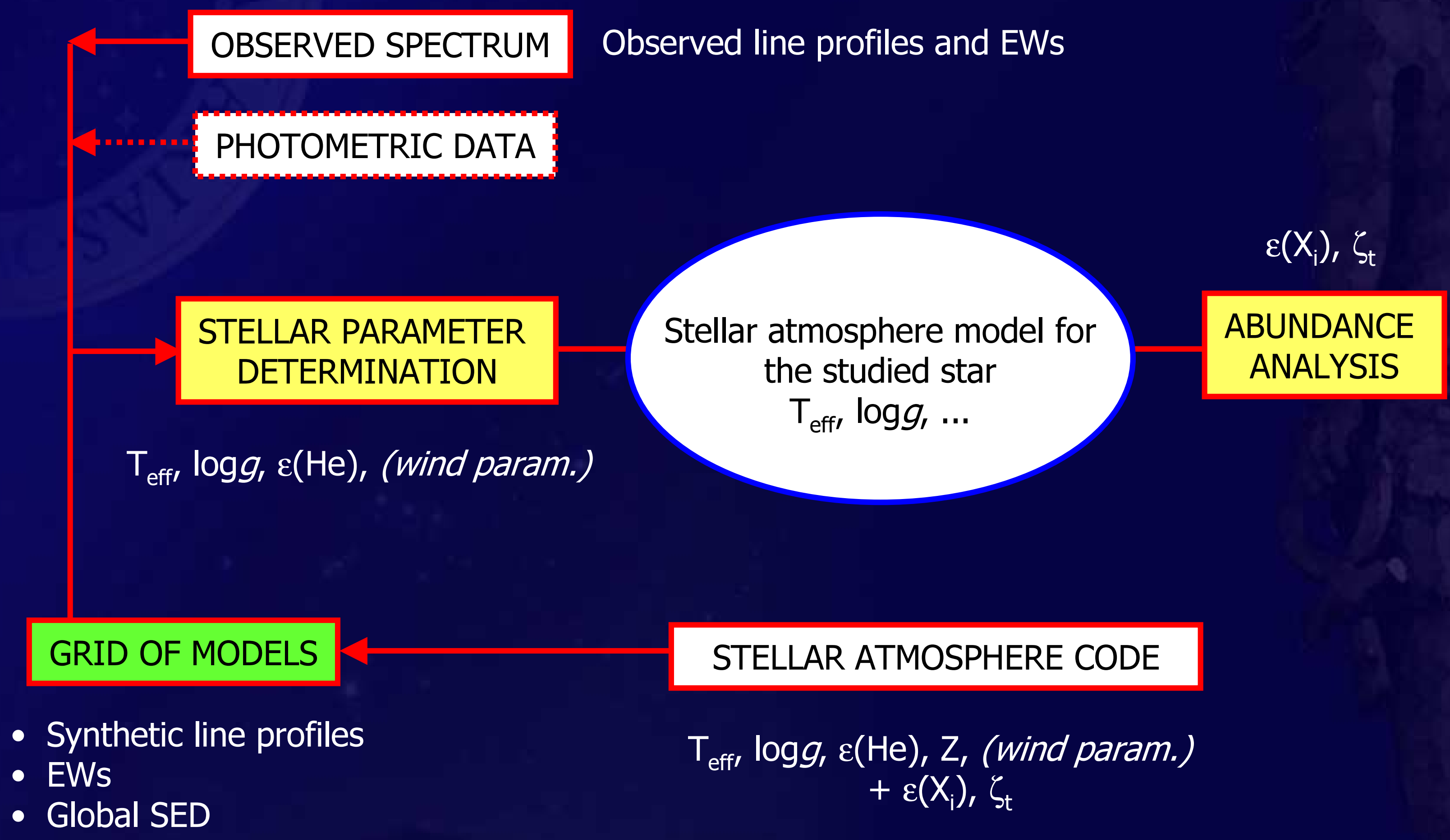




Homogeneous set of O and Si abundances (scatter < intrinsic uncertainties)

→ No clear signatures of contamination of the last generation of stars by SNe type-II ejecta

How to perform a stellar abundance analysis: a general overview



How to perform a stellar abundance analysis: a general overview

Stellar atmosphere code: from the stellar parameters to the synthetic lines

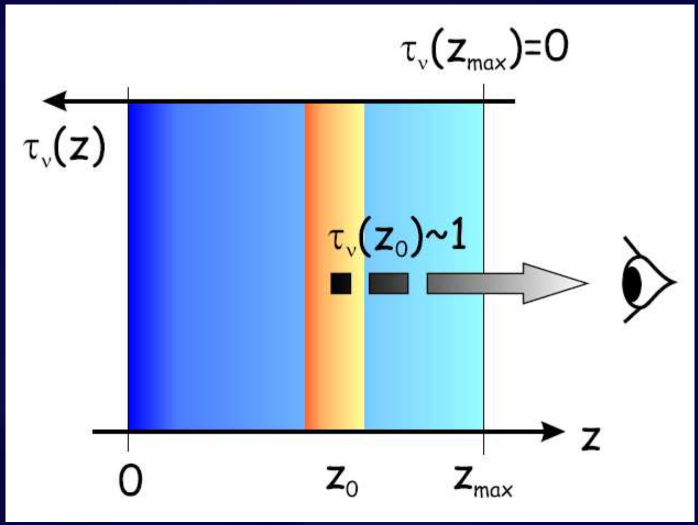
STELLAR ATMOSPHERE CODE

Stellar atmosphere model + Line formation code

Stellar atm. structure: Te(τ), Ne(τ)
Global SED
-- LTE/NLTE, line blanketing --

Level populations: N_{ij} (τ)
Line profiles + EWs
-- LTE/NLTE --

- ATLAS *(Kurucz)*
- TLUSTY *(Hubeny & Lanz)*
- CMFGEN *(Hillier)*
- FASTWIND *(Puls et al.)*
- DETAIL/SURFACE *(Buttler & Giddings)*



How to perform a stellar abundance analysis: a general overview

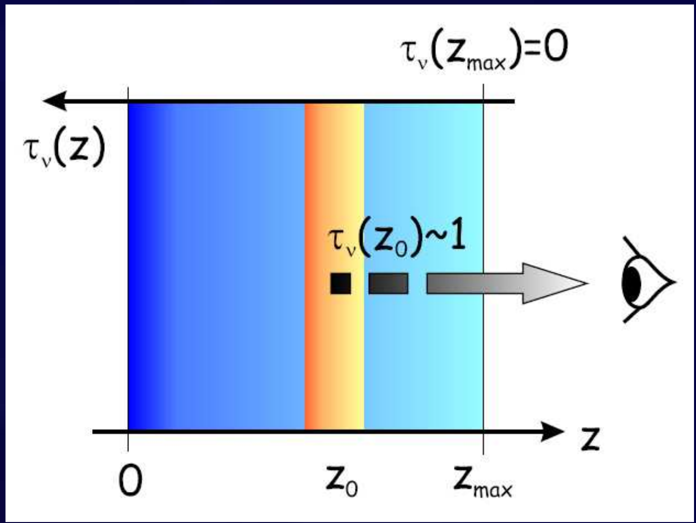
A VERY important step: stellar parameter determination

Use of photometric calibrations vs **Self-consistent spectroscopic approach**

e.g. Lester, Gray & Kurucz (1986)

$[c_1] = c_1 - 0.20\ (b\text{-}y) = f(T_{eff}, \log g)$
Based on Kurucz's (1979) models

T_{eff}, log$g$, ... are determined by using synthetic lines resulting from the same stellar atmosphere code that will be used for the abundance analysis



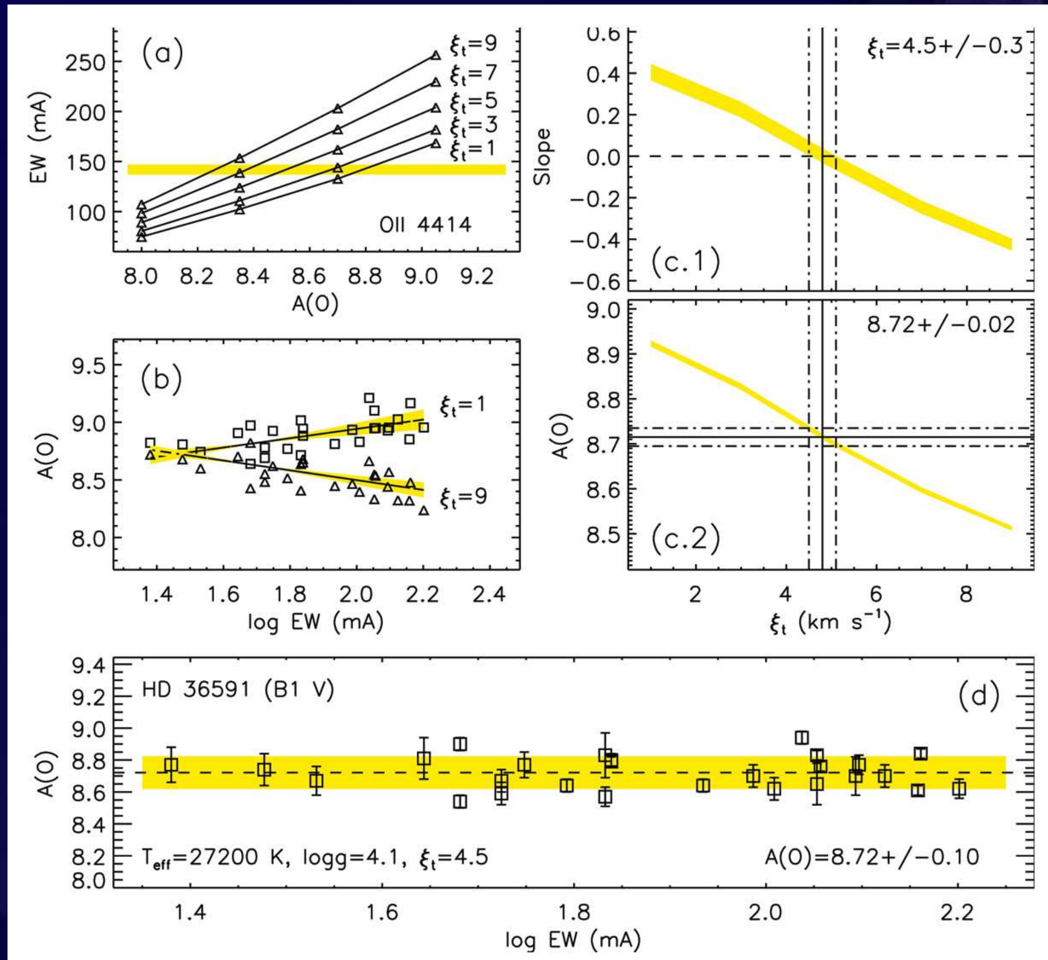
How to perform a stellar abundance analysis: a general overview

Abundance determination: the curve of growth method

For a fixed set of stellar parameters
T_{eff}, log*g*, ε(He), *(wind param.)*

i.e. a given atmosphere structure

Grid of EWs of diagnostic lines
(line formation code)
for different [ε(X), ζ_t] – pairs



What is new/different between CL94 and SD10 ?

1) Stellar atmosphere codes

→ *Cunha & Lambert (1994)*: ATLAS6 (plane-parallel) LTE blanketed models
+ WIDTH6 LTE line formation computations

Gold (plane-parallel) LTE slighly blanketed models
+ NLTE line formation computations

→ *Simón-Díaz (2010):* Spherical NLTE line blanketed models
+ NLTE line formation computations (FASTWIND)

2) Method to establish the stellar parameters

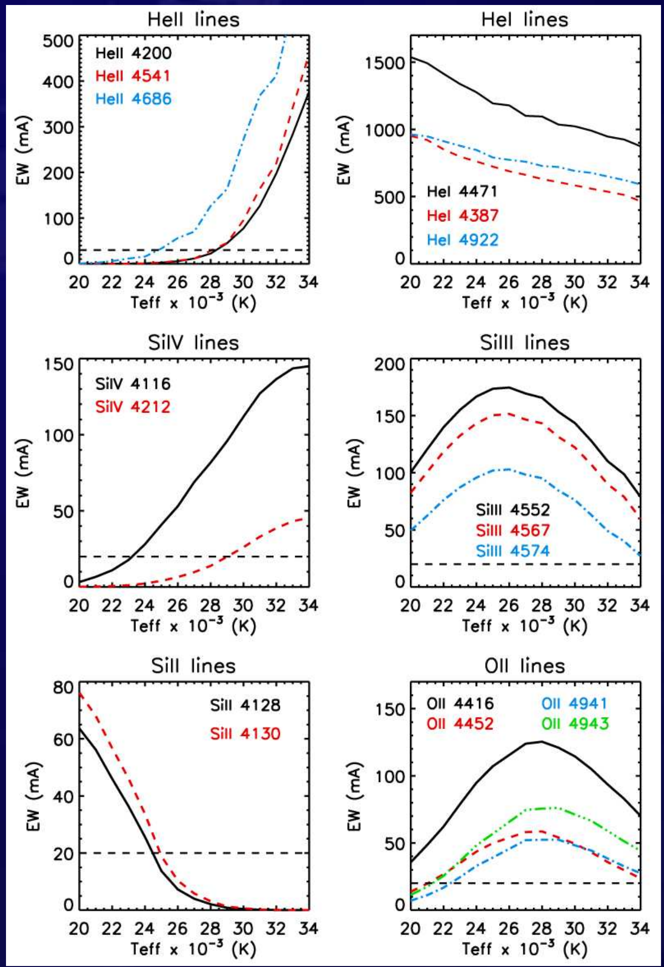
→ *Cunha & Lambert (1994):* Photometric calibrations + Hγ

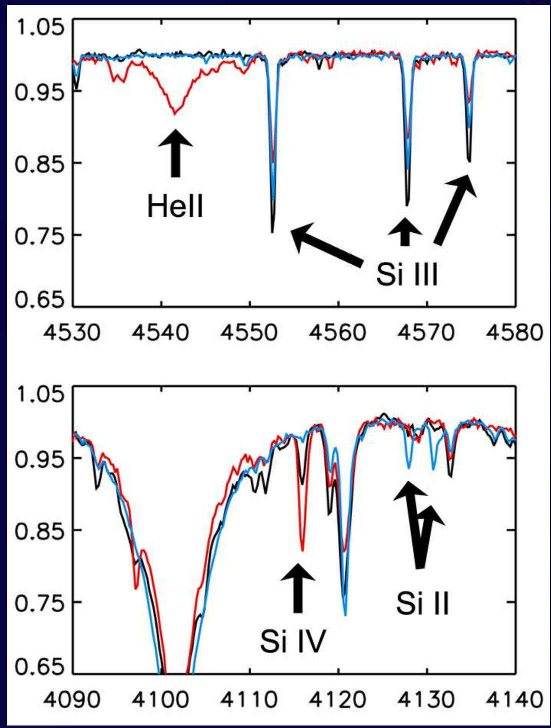
→ *Simón-Díaz (2010):* Self consistent spectroscopic approach (H, He I/II, Si II/III/IV)

3) Different spectroscopic dataset + O and Si lines used in the analysis

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Spectroscopic approach: Si II-IV lines as T_{eff} indicators in B0-B2 V stars





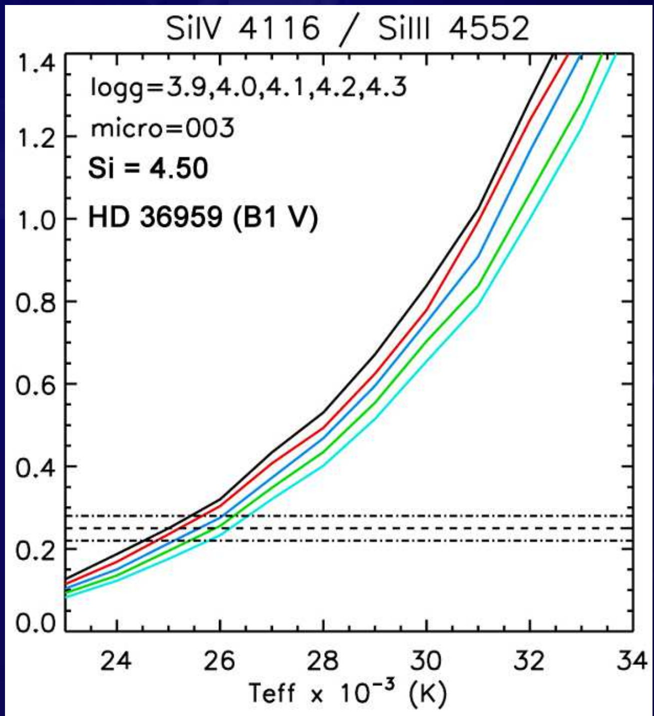
Depending of the star, different Si line ratios must be used as T_{eff} indicators:

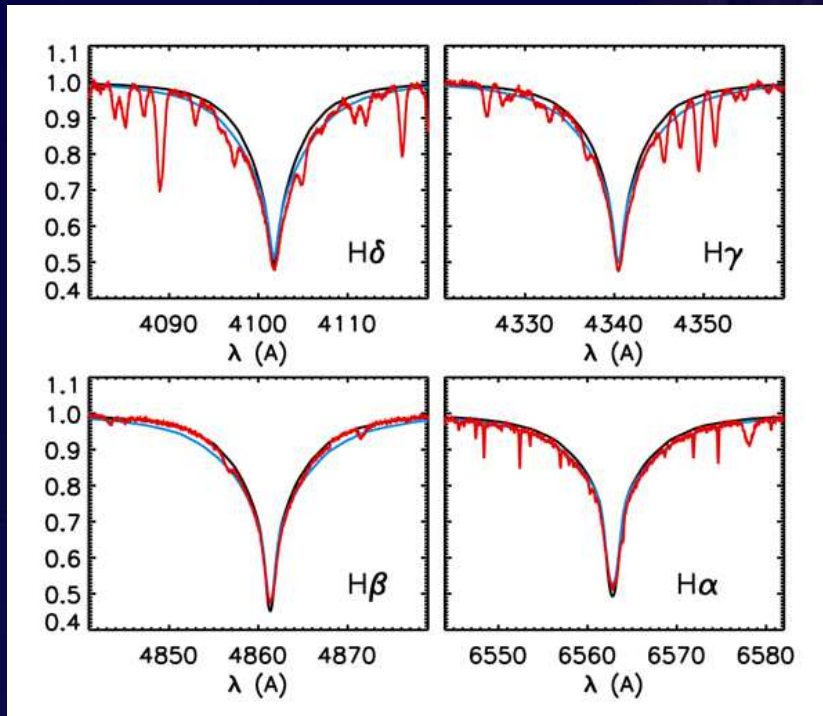
Si IV/III, Si II/III

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Stellar parameter determination: spectroscopic approach

For the hotter objects: Si IV /Si III ionization balance ... and the H Balmer lines



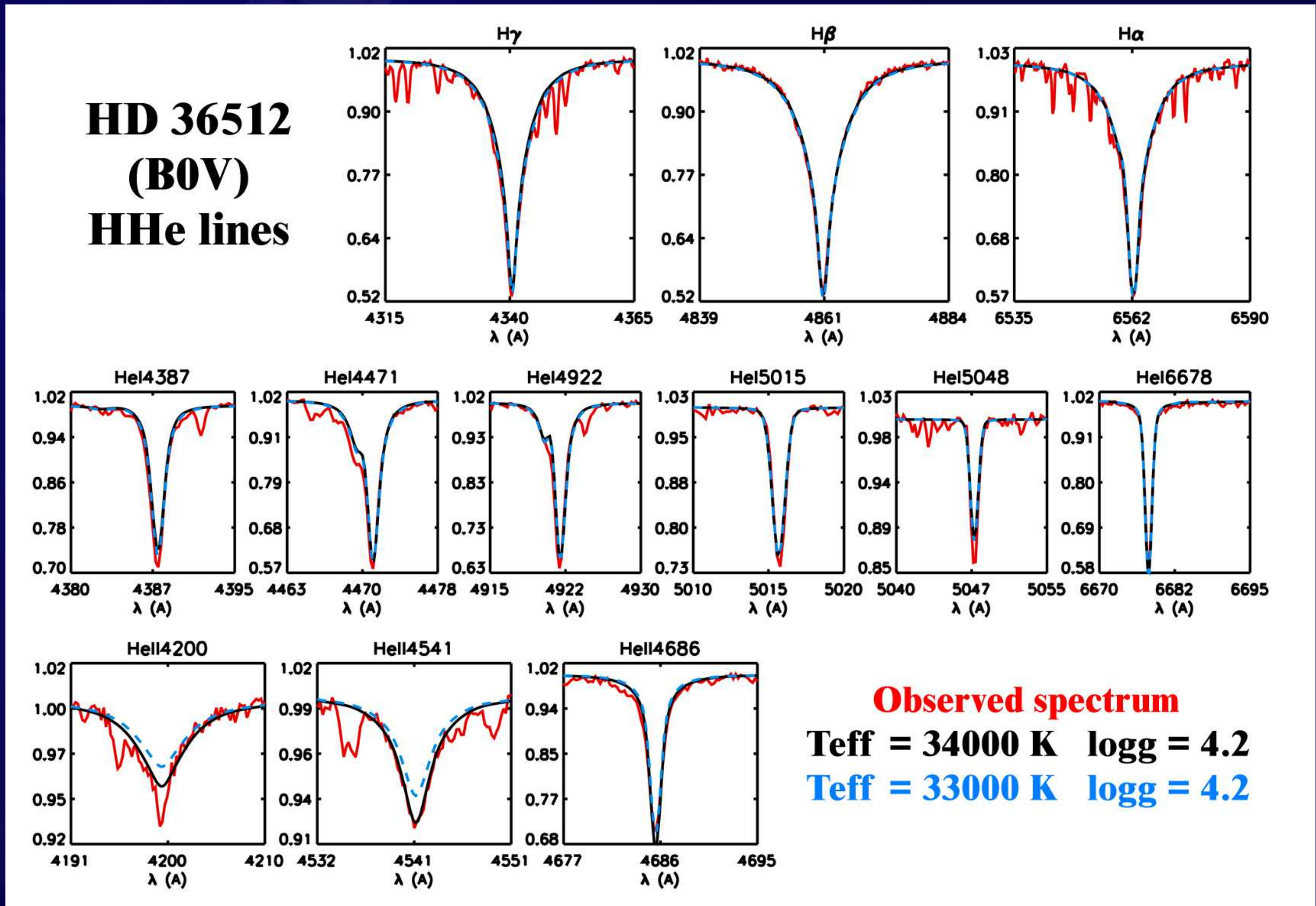


log g = 4.2	log g = 4.3	log g = 4.4
T_{eff}=26000 ± 400 K	T_{eff}=26200 ± 400 K	T_{eff}=26500 ± 400 K

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Stellar parameter determination: spectroscopic approach

... also the He I-II ionization equilibrium (if Teff > 29000 K)



HD 36512 (B0 V)

H-Si analysis

log*g* = 4.2
T_{eff} = 33700 K

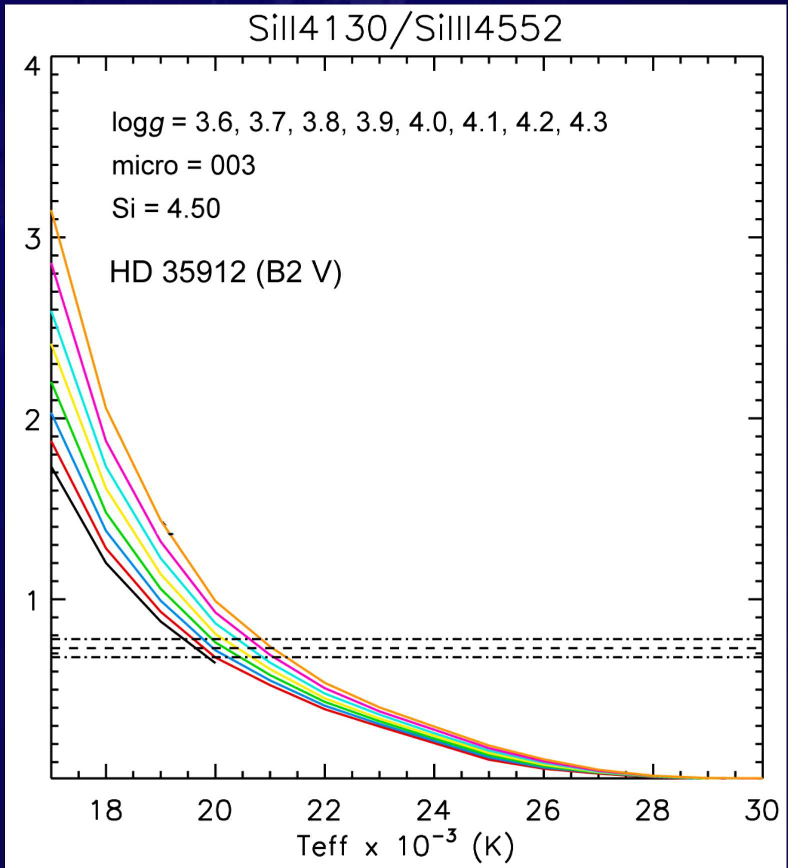
H-He analysis

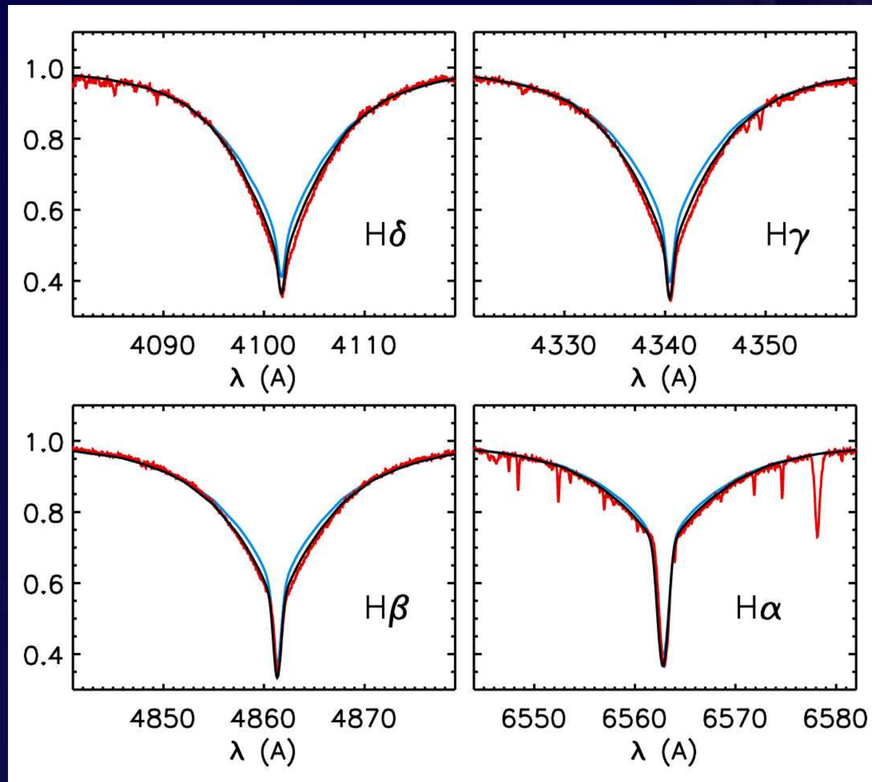
log*g* = 4.2
T_{eff} = 34000 K

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Stellar parameter determination: spectroscopic approach

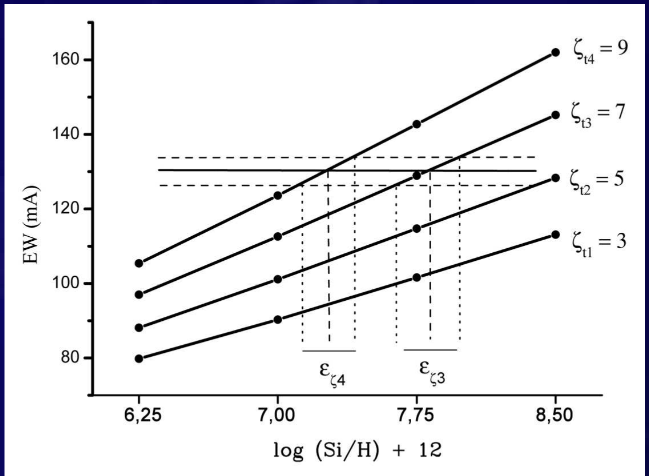
For the cooler objects: Si II /Si III ionization balance ... and the H Balmer lines

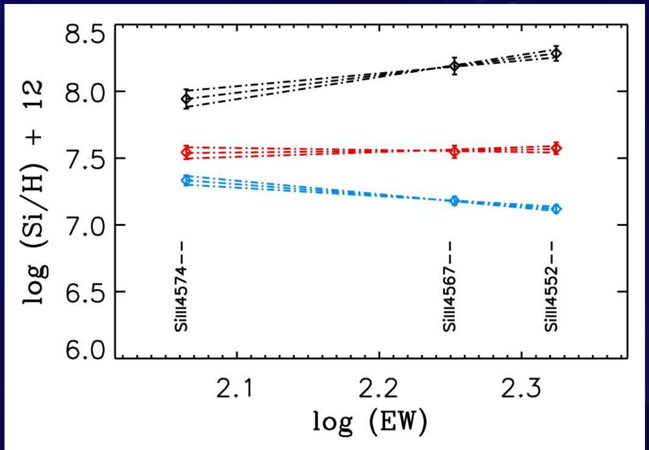




A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Silicon abundance determination + fine-tuning of stellar parameters *(curve of growth)*





- For a given pair (T_{eff}, log$g$), 2 free parameters: (ξ_t, ε(Si))

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

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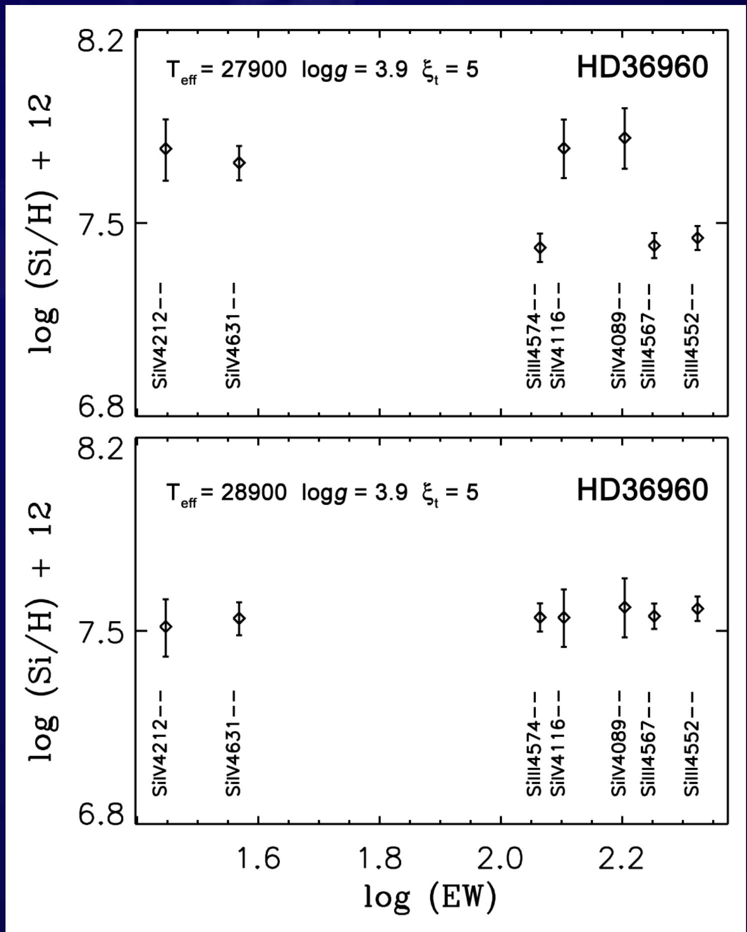
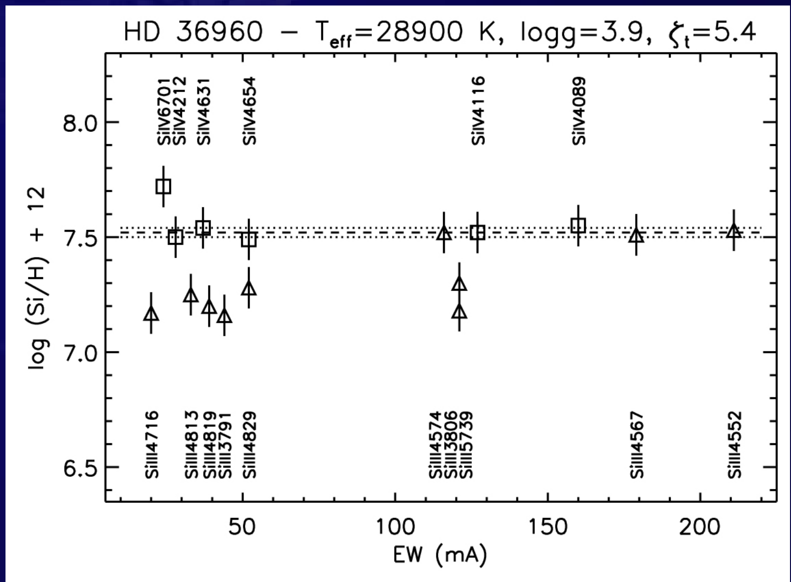


- For a given pair (T*eff*, log*g*), 2 free parameters: (ξ_t, ε(Si))
- Actually, the four parameters are determined at the same time

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Silicon abundance determination + fine-tuning of stellar parameters *(curve of growth)*



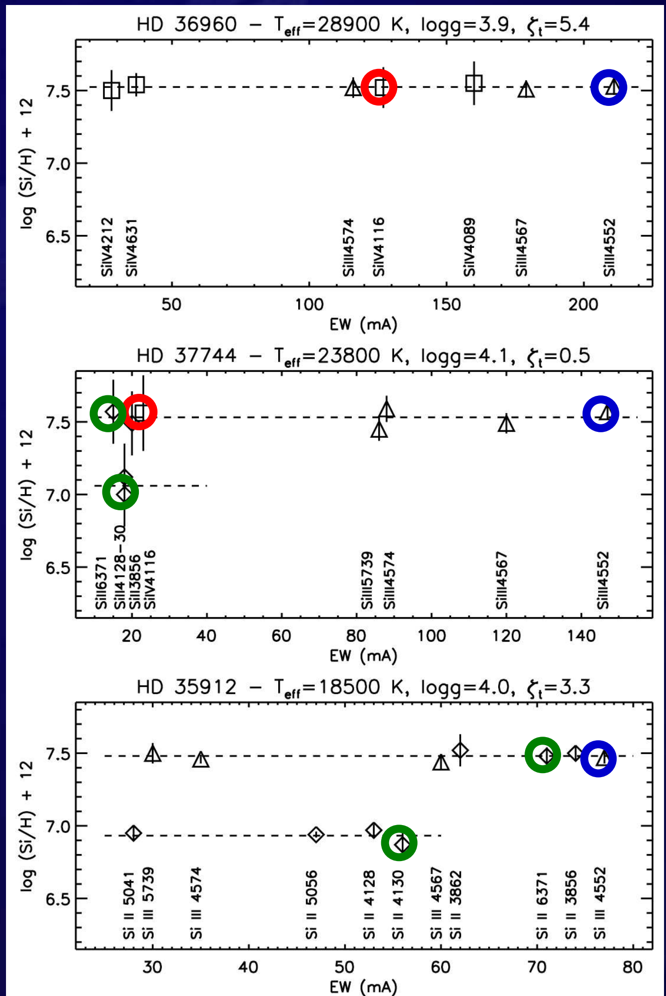
- For a given pair (T*eff*, log*g*), 2 free parameters: (ξ_t, ε(Si))
- Actually, the four parameters are determined at the same time
- Detailed analysis by multiplets

⇩

Identification of *problematic lines* (blends, atomic model ...)

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Silicon abundance determination + fine-tuning of stellar parameters *(curve of growth)*



- For a given pair ($Teff$, log$g$), 2 free parameters: (ξ_t, ε(Si))
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⇓

Identification of *problematic lines* (blends, atomic model ...)

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Results from the analysis: (I) Stellar parameters and Si abundances

Target	SpT	T_{eff} – Si IV-III	T_{eff} – Si II-III	T_{eff} – Si II-III	T_{eff} – He I-II	Adopted T_{eff}	Adopted log g	ξ_t(Si)	$\epsilon_{Si} \pm \Delta\epsilon_{Si} [\sigma, \xi_t]$
HD 36512	B0 V	33700±200	—	—	34000±500	33700	4.2	4.3±0.7	7.49± [0.07, 0.05]
HD 37020	B0.5 V	30500±600	—	—	30000±500	30500	4.2	0.5±0.5	7.47± [0.10, 0.04]
HD 36960	B0.5 V	28900±300	—	—	29000±500	28900	3.9	5.4±0.6	7.53± [0.02, 0.06]
HD 37042	B0.7 V	29700±400	—	—	29500±500	29700	4.2	1.4±0.3	7.55± [0.03, 0.04]
HD 36591	B1 V	27200±100	—	—	—	27200	4.1	1.3±0.3	7.53± [0.06, 0.03]
HD 36959	B1 V	25900±300	25900±100	—	—	25900	4.2	0.0±1.0	7.50± [0.05, 0.07]
HD 37744	B1.5 V	23900±600	25700±100	23600±600	—	23800	4.1	0.5±0.5	7.54± [0.06, 0.04]
HD 35299	B1.5 V	23900±300	24900±300	23700±300	—	23700	4.2	0.5±0.5	7.50± [0.08, 0.02]
HD 36285	B2 V	—	23900±200	20600±200	—	20600	4.0	1.7±0.5	7.49± [0.06, 0.05]
HD 35039	B2 V	—	22200±200	19900±200	—	19800	3.7	3.3±1.0	7.52± [0.06, 0.08]
HD 36629	B2 V	—	22800±300	20000±100	—	20000	4.1	1.0±0.5	7.54± [0.04, 0.05]
HD 36430	B2 V	—	21000±300	18600±200	—	18600	4.1	3.5±1.0	7.47± [0.08, 0.07]
HD 35912	B2 V	—	20400±300	18500±150	—	18500	4.0	3.2±0.5	7.48± [0.07, 0.04]

Si IV 4116 / Si III 4552	~~Si II 4130 / Si III 4552~~	Si II 6371 / Si III 4552

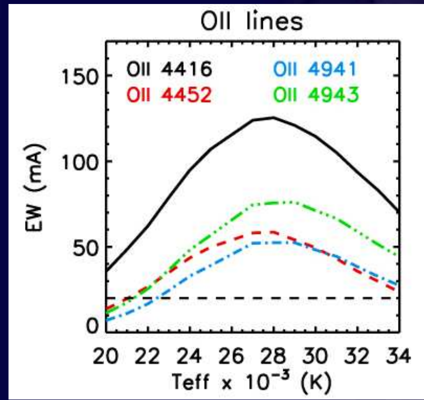
Total uncertainty ~ ± 0.07 – 0.09 dex

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

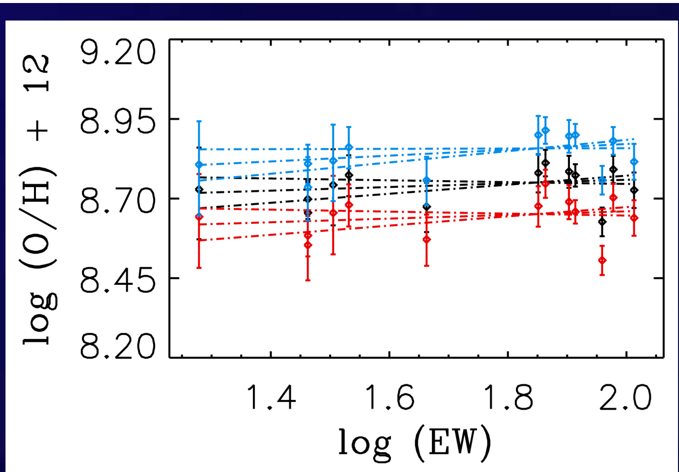
Oxygen abundance analysis: method and uncertainties

→ Method: similar to Si, but only with O II lines

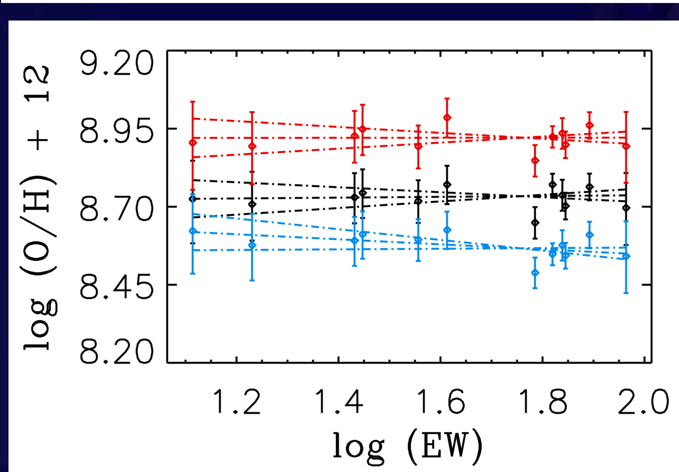
1) Uncertainty due to EW measurement
2) Uncertainty due to microturbulence determination
3) Uncertainty due to line dispersion
4) **Uncertainty due to stellar parameter determination**



HD36512 log$g$ = 4.2 T_{eff}= 33, 34, 35 kK



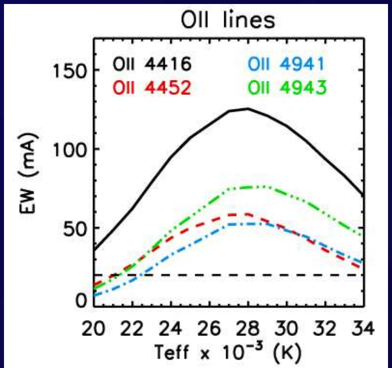
HD35299 log$g$ = 4.2 T_{eff}= 23, 24, 25 kK



A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Results from the analysis: (II) O abundances

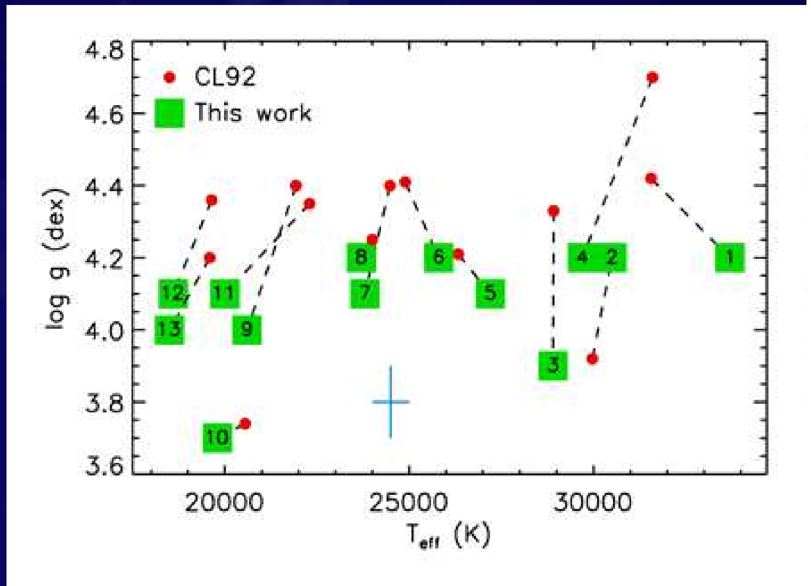
Target	SpT	T_{eff}	log g	$\xi_t(O)$	ϵ_O	$\Delta\epsilon_O(\sigma)$	$\Delta\epsilon_O(\xi_t)$	$\Delta\epsilon_O(T_{eff})$	$\epsilon_O(T_{eff}+500, T_{eff}-500)$
HD 36512	B0 V	33700	4.2	4.4±1.5	8.71	0.10	0.05	0.06	(8.76, 8.65)
HD 37020	B0.5 V	30500	4.2	6.4±1.6	8.70	0.10	0.07	0.05	(8.74, 8.65)
HD 36960	B0.5 V	28900	3.9	5.9±0.8	8.71	0.10	0.04	0.03	(8.74, 8.68)
HD 37042	B0.7 V	29700	4.2	4.9±1.1	8.75	0.08	0.06	0.02	(8.78, 8.74)
HD 36591	B1 V	27200	4.1	4.5±0.3	8.71	0.10	0.02	0.02	(8.71, 8.74)
HD 36959	B1 V	25800	4.2	2.1±0.4	8.70	0.06	0.02	0.05	(8.66, 8.76)
HD 37744	B1.5 V	23800	4.1	3.6±1.4	8.70	0.07	0.06	0.09	(8.61, 8.79)
HD 35299	B1.5 V	23700	4.2	2.8±0.6	8.72	0.07	0.03	0.09	(8.64, 8.82)
HD 36285	B2 V	20600	4.0	5.5±1.5	8.80	0.10	0.06	0.13	(8.67, 8.92)
HD 35039	B2 V	19800	3.7	5.3±1.5	8.79	0.07	0.07	0.15	(8.65, 8.94)
HD 36629	B2 V	20000	4.1	6.0±1.7	8.76	0.10	0.06	0.14	(8.62, 8.89)
HD 36430	B2 V	18600	4.1	6.3±2.2	8.76	0.07	0.08	0.13	(8.64, 8.90)
HD 35912	B2 V	18500	4.0	6.3±2.2	8.79	0.09	0.08	0.13	(8.67, 8.93)

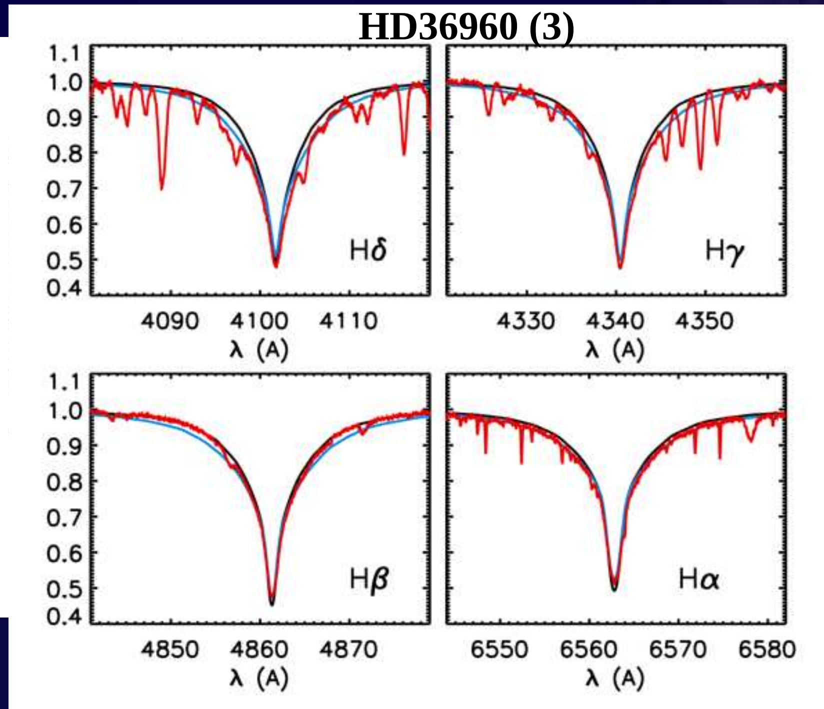


Total uncertainty ~ ± 0.08 – 0.12 dex

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Comparison with results from CL94: stellar parameters

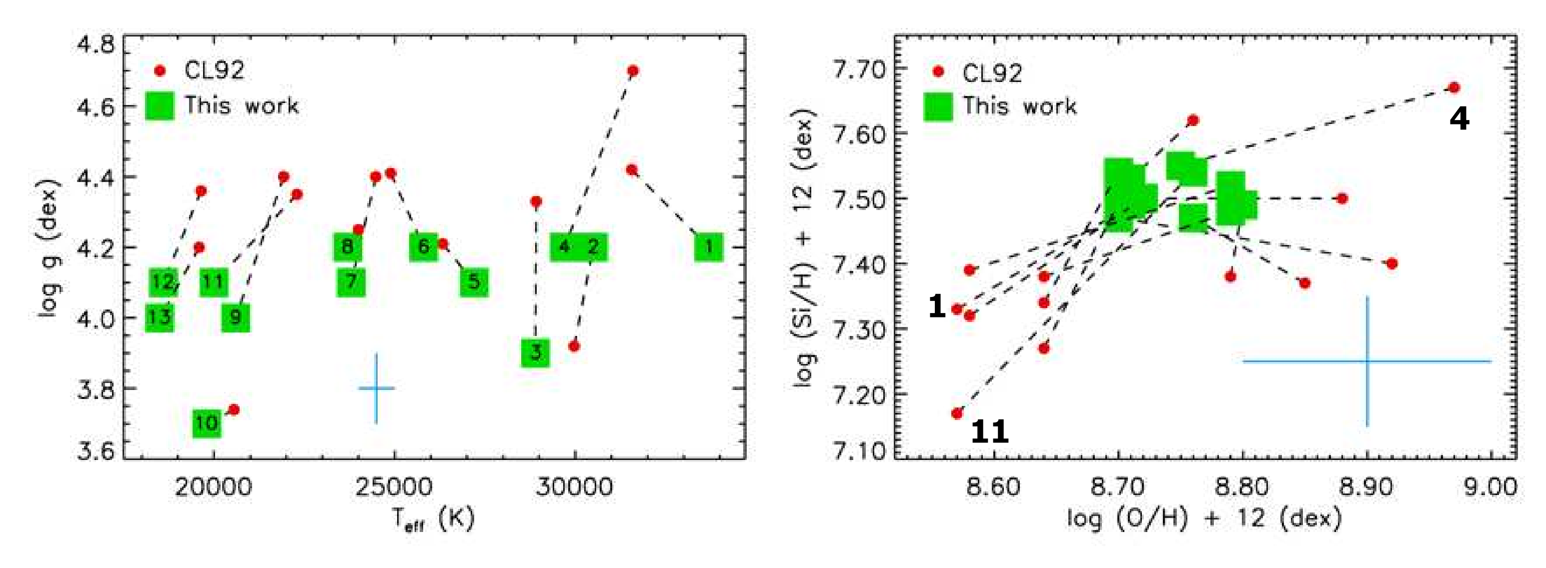




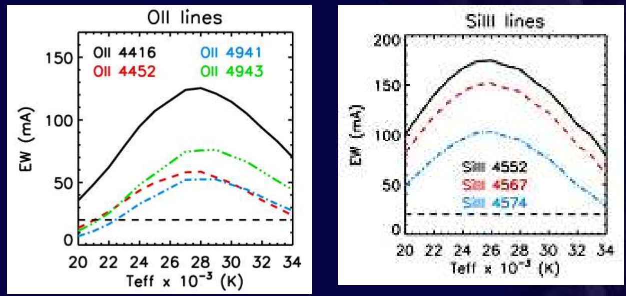
1) Important discrepancies in the derived stellar parameters

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Comparison with results from CL94: O and Si abundances

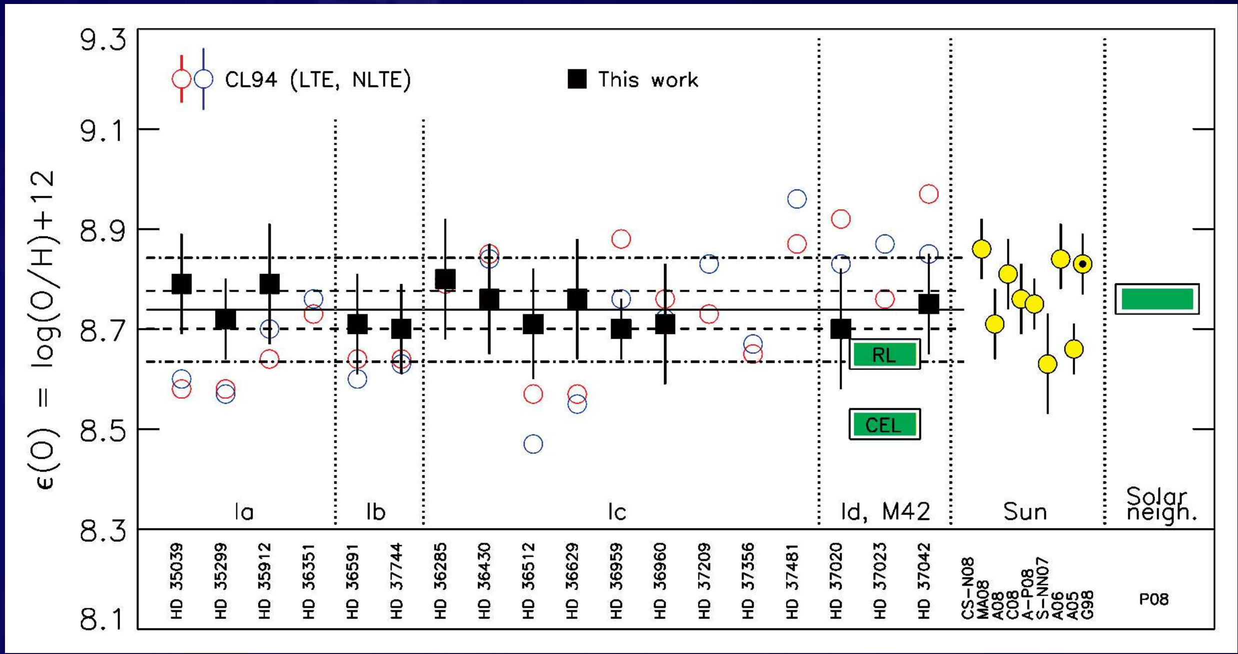


1) Important discrepancies in the derived stellar parameters
2) O and Si abundances are more homogeneous than previously estimated !!
3) Dispersion of abundances is smaller than intrinsic uncertainties



A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Summary of results regarding oxygen



Orion OB1

Simón-Díaz (2010)

ε(O) = 8.73 ± 0.04

Solar neighbourhood

Przybilla et al (2008)

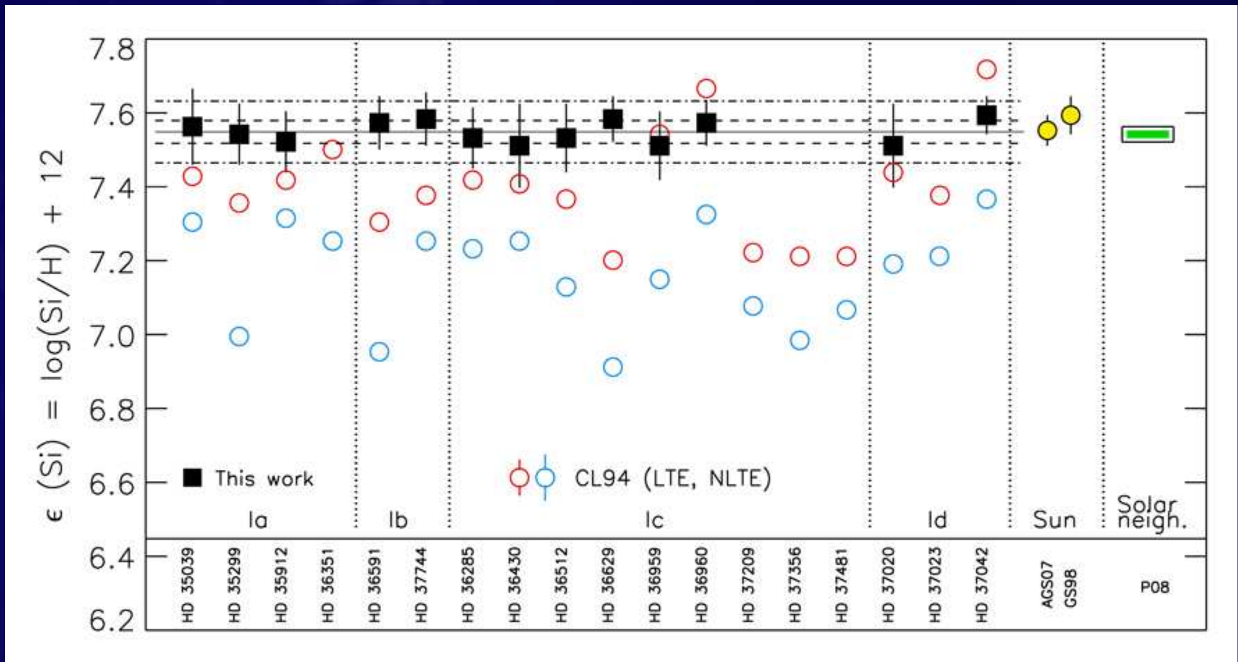
Nieva & Przybilla (2012)

ε(O) = 8.76 ± 0.05

- Homogeneous set of oxygen abundances
- Scatter (0.04) < intrinsic uncertainties (0.10)
- Newly formed stars contaminated by type-II SNe ejecta?
- Same mean value and scatter as in the rest of the Solar neighbourhood

A new analysis of the B-type stars in Ori OB1 *(Simón-Díaz 2010)*

Summary of results regarding silicon



Orion OB1

Simón-Díaz (2010)

ε(Si) = 7.51 ± 0.03

Solar neighbourhood

Przybilla et al (2008)

Nieva & Przybilla (2012)

ε(Si) = 7.50 ± 0.06

- Homogeneous set of silicon abundances
- Scatter (0.03) < intrinsic uncertainties (0.08)
- Very good agreement with *P08* and *AGS07*

  → Si (B-type stars) not subsolar any more !!

CL94 – *Cunha & Lambert (1994)*
P08 – *Przybilla et al. (2008)*
G98 – *Grevesse & Sauval (1998)*
AGS07 – *Asplund et al. (2007)*

The chemical composition of early-B type stars in Ori OB1 *(Cunha & Lambert 1994)*

THE ASTROPHYSICAL JOURNAL, 426:170–191, 1994 May 1

CHEMICAL EVOLUTION OF THE ORION ASSOCIATION. II. THE CARBON, NITROGEN, OXYGEN, SILICON, AND IRON ABUNDANCES OF MAIN-SEQUENCE B STARS

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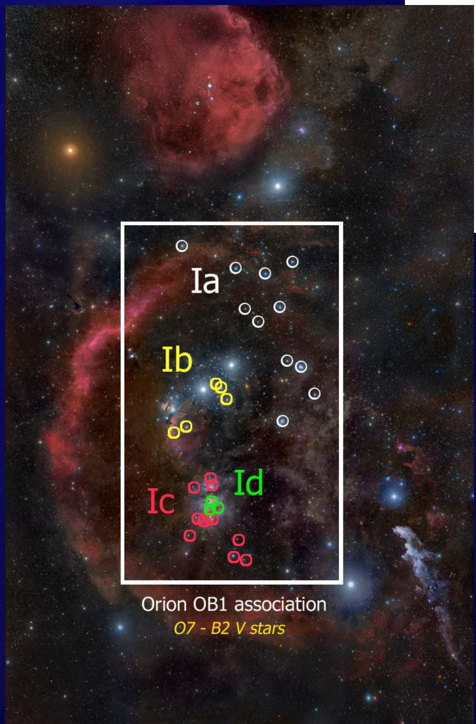
Received 1993 September 17; accepted 1993 November 3

ABSTRACT

Carbon, nitrogen, oxygen, and silicon abundances are presented from LTE and non-LTE analyses of C II, N II, and Si III lines in the spectra of 18 main-sequence B stars from the four subgroups comprising the Orion association. Iron LTE abundances from Fe III lines are also presented. The C, N, and Fe abundances show no significant variations across the subgroups, but the O and Si abundances are found to be higher for some of the youngest stars that are collocated on the sky and at a common distance. The O and Si abundances are correlated. Although such a correlation may in part reflect measurement errors, it is suggested that the enrichment of young stars in O and Si arose because they were formed from regions of the molecular cloud enriched with the ejecta of Type II supernovae, which are predicted to be rich in O and Si but not in C and N. With the exception of one star, we see no evidence for CN-cycled material on the stars' surfaces. The stellar abundances agree, within the expected uncertainties, with published nebular analyses that show Orion to be slightly underabundant in C, N, and O relative to the Sun.

Subject headings: open clusters and associations: individual (Orion I) — stars: abundances — stars: early-type



Orion OB1 association
O7 - B2 V stars

5. Conclusions

[...] O and Si, on the other hand, exhibit larger abundance variations than can be accounted for by the identifiable errors and, hence, either the errors have been incorrectly characterized for Si and O, or the abundance variations are real. [...]

A new analysis of the B-type stars in Ori OB1 *(Nieva & Simón-Díaz 2011)*

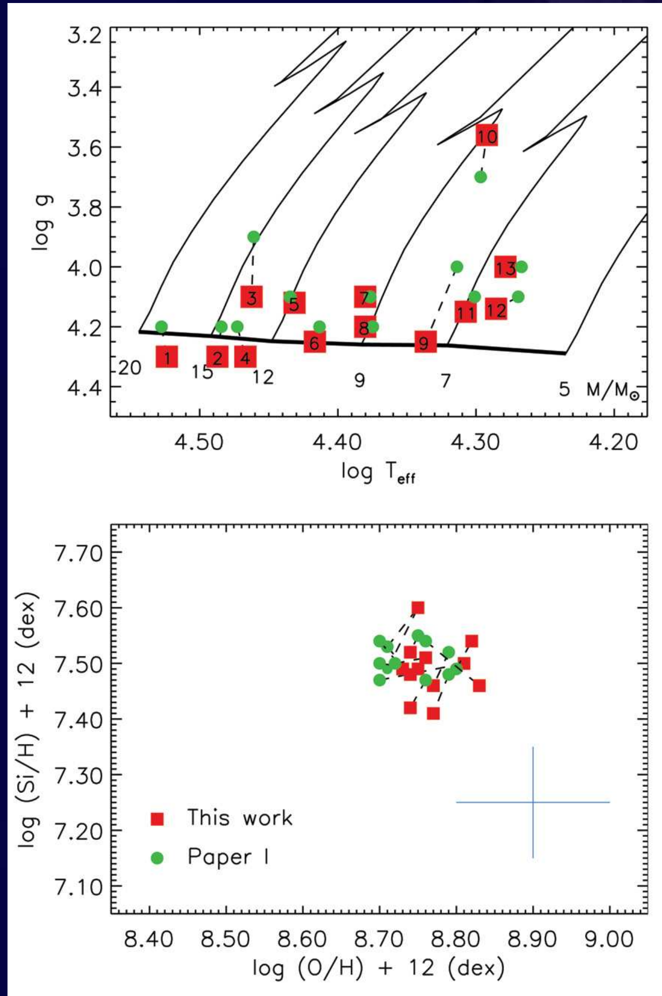
What about the other abundances derived by CL94?

Simón-Díaz (2010)

- O and Si abundances
- FASTWIND (NLTE)
- Spectroscopic approach: H, Si II/III/IV, O II
- Curve of growth

Nieva & Simón-Díaz (2011)

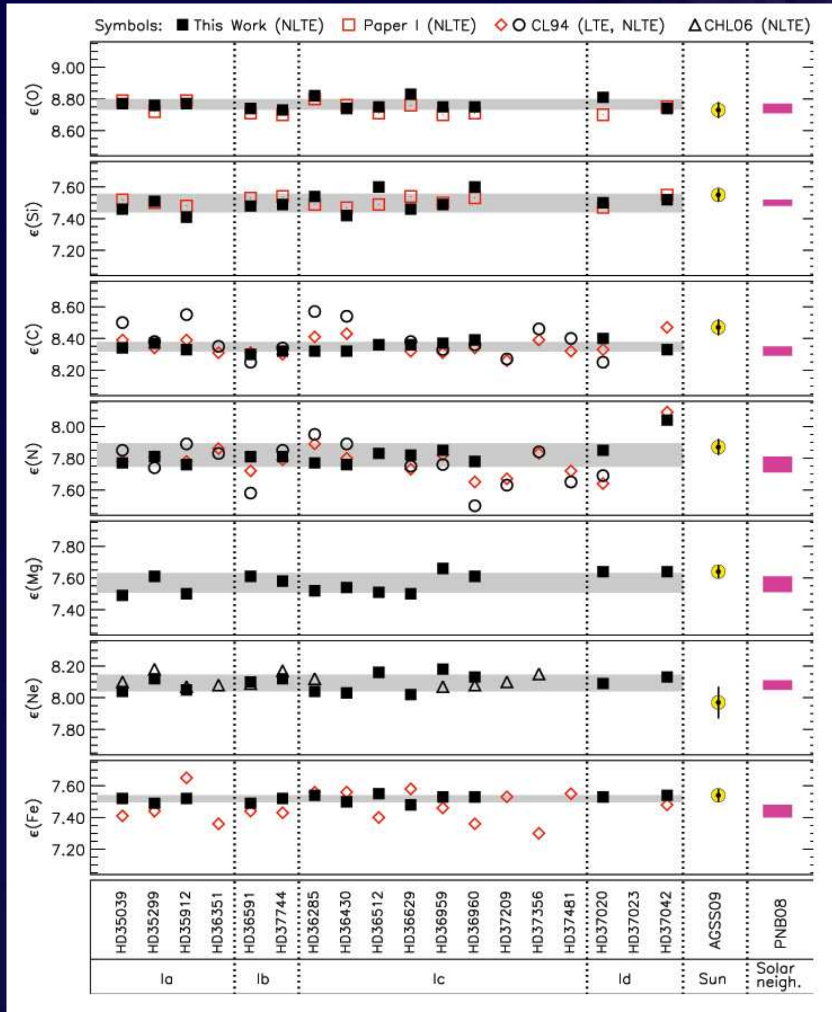
- C, N, O, Ne, Si, Mg, Fe abundances
- TLAS (LTE) +DETAIL/SURFACE (NLTE)
- Spectroscopic approach: H, C II/III, O I/II, Ne I/II, Si III/IV, Fe II/III, N II
- Spectral synthesis



A new analysis of the B-type stars in Ori OB1 *(Nieva & Simón-Díaz 2011)*

What about the other abundances derived by CL94?

	CL94		NS-D11
	LTE	NLTE	
O	8.73 ± 0.13	8.72 ± 0.13	8.77 ± 0.03
Si	7.36 ± 0.14	7.14 ± 0.13	7.50 ± 0.06
C	8.35 ± 0.06	8.40 ± 0.11	8.35 ± 0.03
N	7.79 ± 0.11	7.76 ± 0.13	7.82 ± 0.07
Fe	7.47 ± 0.10		7.52 ± 0.02
Mg			7.57 ± 0.06
Ne			8.09 ± 0.05



- Not very different mean values (except for Si)
- BUT smaller scatter

Chemical abundance studies of early-B stars in Orion OB1

Neon *(Cunha et al. 2006)* & Argon *(Lanz et al. 2008)*

A(Ne)* = 8.11 +/- 0.04 dex (Used ions: Ne I)
A(Ar)* = 6.66 +/- 0.06 dex (Used ions: Ar II)

- Stellar parameters (Teff, logg) adopted from CL94
- TLUSTY/SYNSPECT NLTE atmospheres + NLTE line formation

Sulfur *(Daflon et al. 2009)*

A(S)* = 7.15 +/- 0.05 dex (Used ions: S II/III)

- Stellar parameters (Teff, logg) adopted from CL94 + fine-tuning if A(SIII-SII) > 0.15 dex
- ATLAS LTE blanketed atmospheres + DETAIL/SURFACE NLTE

* 11 B-type stars from the original sample by CL92 (Ia, Ib, Ic)
Excluded stars: HD36430 (B2V), HD36512 (B0V),
HD36629 (B2V), HD37481 (B1.5 IV),
HD37020 (B0.5V), HD37023 (SB2), HD37042 (B0.7 V)

Conclusions

- Recent accurate abundance analyses of B-type stars in the OriOB1 association have shown that the dispersion of O and Si abundances between stars in the various subgroups found in previous analyses is a spurious result and the consequence of a bad characterization of the abundance errors propagated from the uncertainties in the stellar parameter determination.

- The present day abundances of B-type stars in Ori OB1 are compatible at similar precision with other B-type stars in the Solar neighbourhood *(Nieva & Przybilla 2012)* and also with the last revision of abundances in the Sun *(Asplund et al. 2009)*

ADDENDUM

Orion OB1: B-type stars vs. nebular (M42) abundances

(Simón-Díaz & Stasinska 2011 + extra information)

Orion OB1: B-type stars vs nebular (M42) abundances

Elem.	B-type stars (OriOB1)	M42 (E02)		M42 (S-DS11)	
		CEL	ORL	CEL	ORL
O	8.74 ± 0.04 †	8.51 ± 0.03	8.63 ± 0.03	8.52 ± 0.01	8.65 ± 0.03
O (g+d)		8.64 – 8.67	8.72 – 8.77	8.65 - 8.68	8.74 – 8.79
C	8.35 ± 0.03 †	---	8.42 ± 0.02	---	8.37 ± 0.03
N	7.82 ± 0.07 †	7.65 ± 0.09	---	7.68 ± 0.10 (a)	
				7.92 ± 0.09 (b)	---
Ne	8.09 ± 0.05 †	7.78 ± 0.07	8.16 ± 0.2	7.84 ± 0.03 (a)	8.03 ± 0.26 (a)
				8.05 ± 0.03 (b)	8.25 ± 0.35 (b)
S	7.15 ± 0.05 ††	7.06 ± 0.04	---	6.87 ± 0.05 (b)	---
Ar	6.66 ± 0.06 †††	6.50 ± 0.05	---	6.39 ± 0.03 (b)	---

† *Simón-Díaz (2010)* + *Nieva & Simón-Díaz (2011)*
†† *Daflon et al. (2009)*
††† *Lanz et al. (2008)*

(a) Classical icf
(b) icf own model

E02: *Esteban et al. (2002)*
S-DS11: *Simón-Díaz & Stasinska (2011)*

Rubin et al. (2010): IR[NeII] + IR[NeIII] = 8.01 ± 0.01 dex

Orion OB1: B-type stars vs nebular (M42) abundances *(Simón-Díaz & Stasinska 2011)*

Taking care of O depletion onto dust grains... *(see also Esteban et al. 1998)*

Draine (2003)

Table 3: Dust composition possibilities considered in this study

Silicates	Composition
A	(x)$MgSiO_3$, (1-x)$FeSiO_3$
B	$MgFeSiO_4$
C	(x)Mg_2SiO_4, (1-x)Fe_2SiO_4
Others	A+B, A+C, B+C, A+B+C
Mg oxides	**Composition**
	MgO
Fe oxides	**Composition**
	(x)FeO, (y)Fe_2O_3, (1-x-y)Fe_3O_4

Elem.	Stars	Gas phase (M42)	
Si	7.51 ± 0.03 †	6.50 ± 0.25	Rubin et al. (1993)
Mg	7.57 ± 0.06 †	6.50 ::	Baldwin et al. 1991
Fe	7.50 ± 0.04 †	6.0 ± 0.3	Rodríguez & Rubin (2005)

O (dust) = 125 – 135 ppM (± 10 ppm)

O	Stars	Gas	Gas + dust
	8.74 ± 0.04		
CEL		8.52 ± 0.01	8.65 – 8.68
RL		8.65 ± 0.03	8.74 – 8.79

Dust correction (O) = 0.09 – 0.16 dex