Impact of Non-LTE effects on the CaT and the MgI 8736 Å EWs

in late type giant and super-giant stars

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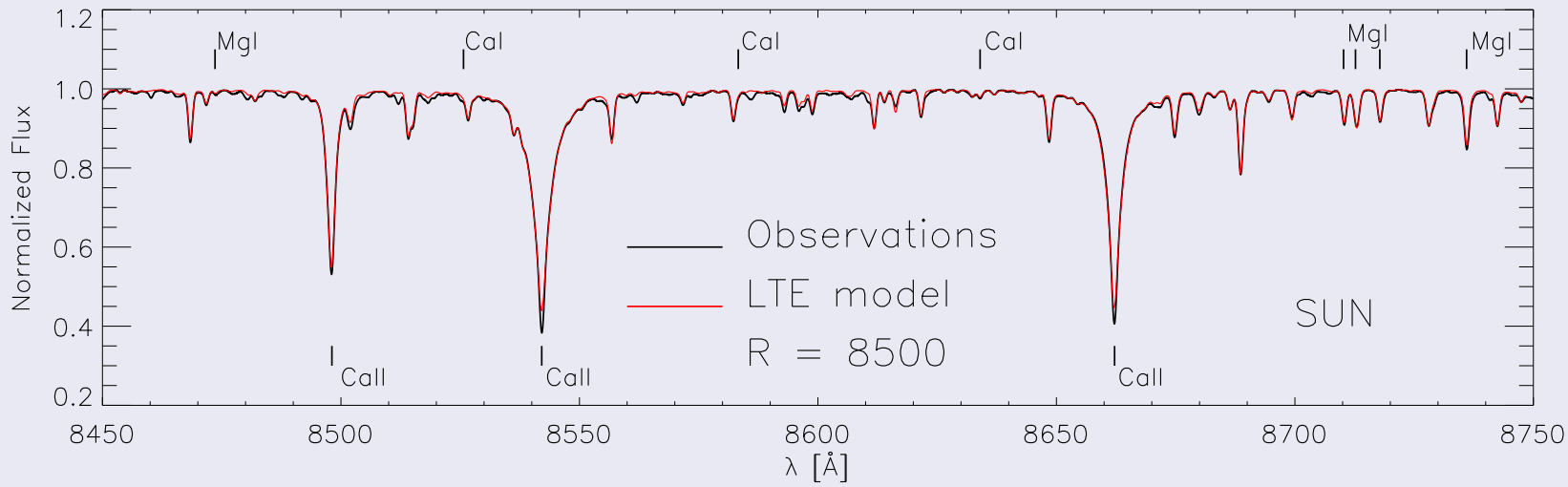
Why CaT and MgI 8736 Å lines are important?

For the RVS*Gaia* wavelength range



For the galactic stellar populations

- Metallicity–CaT calibration relation for globular clusters (Armandroff and Da Costa, 1991) and dSph galaxies (Battaglia et al., 2008; Starkenburg et al., 2010)
- Abundances of α-elements for constraining the chemical evolution of the Galaxy (e.g. Matteucci 2009).

How to compute line profile in NLTE?

NLTE Radiative transfer code: MULTI

(Carlsson, 1986)

`http://folk.uio.no/matsc/mul22`

- solves consistently radiative transfer and statistical equilibrium equations
- LTE: $F_\nu = f(S(T), \kappa(T, n_e, n_i^*))$
- NLTE: $F_\nu = f(S(T, n_i, n_j), \kappa(T, n_e, n_i))$

Model atmospheres: MARCS

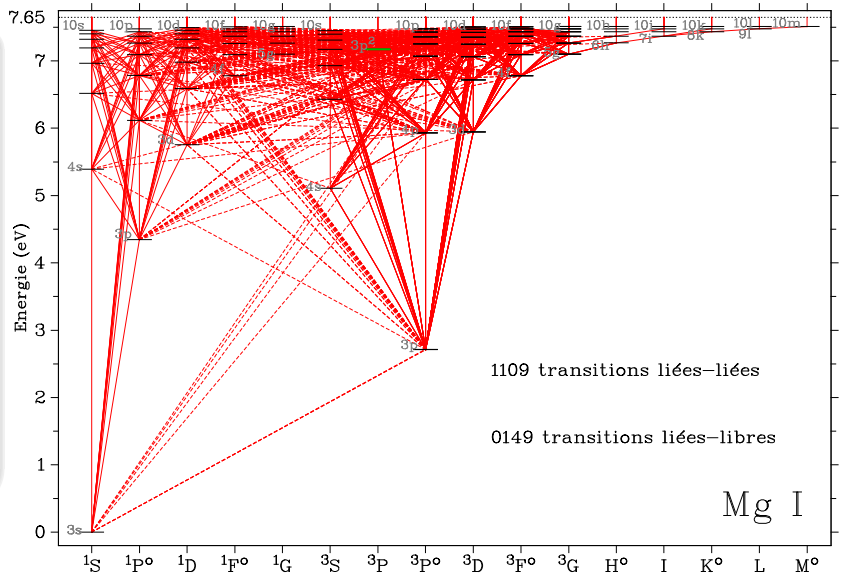
(Gustafsson et al., 2008)

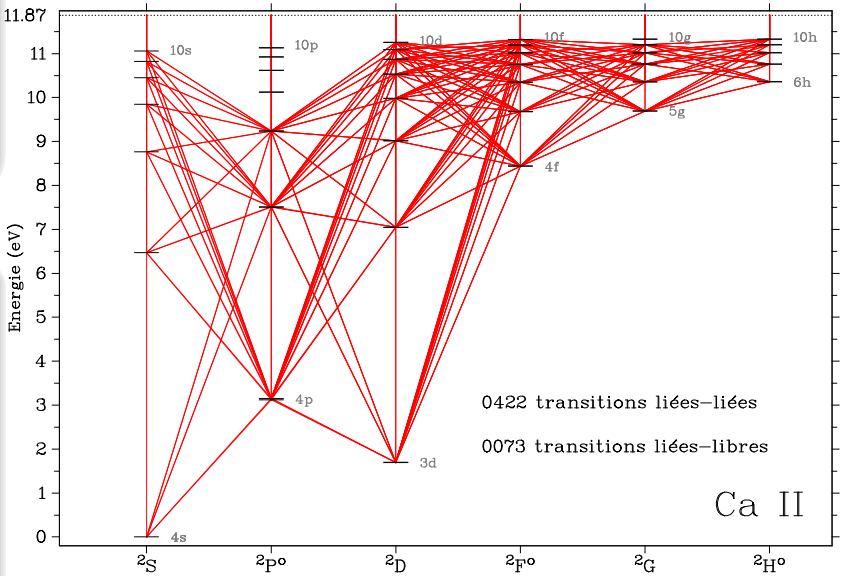
- T, n_e profiles and chemical composition

Model atom: FORMATO

(Merle et al., 2011)

- including levels until $n = 10$
- including recent atomic data
- including fine structure





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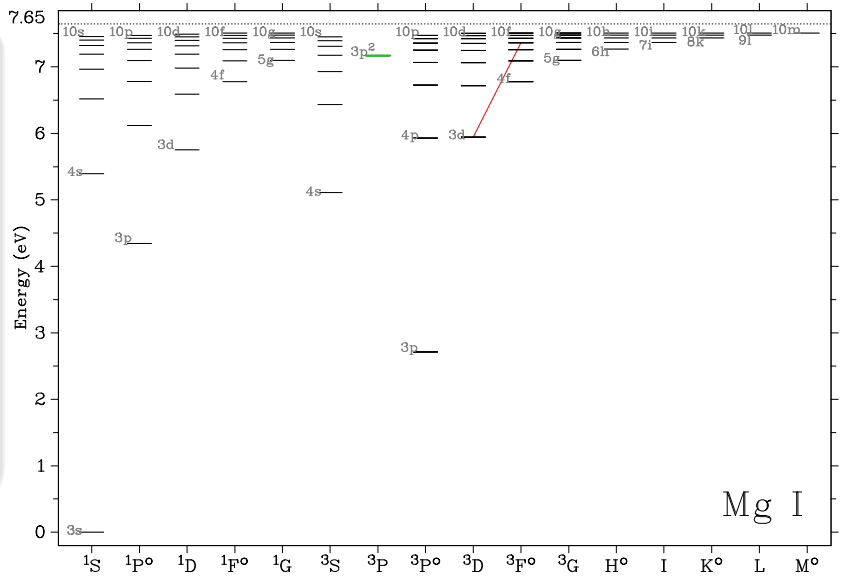
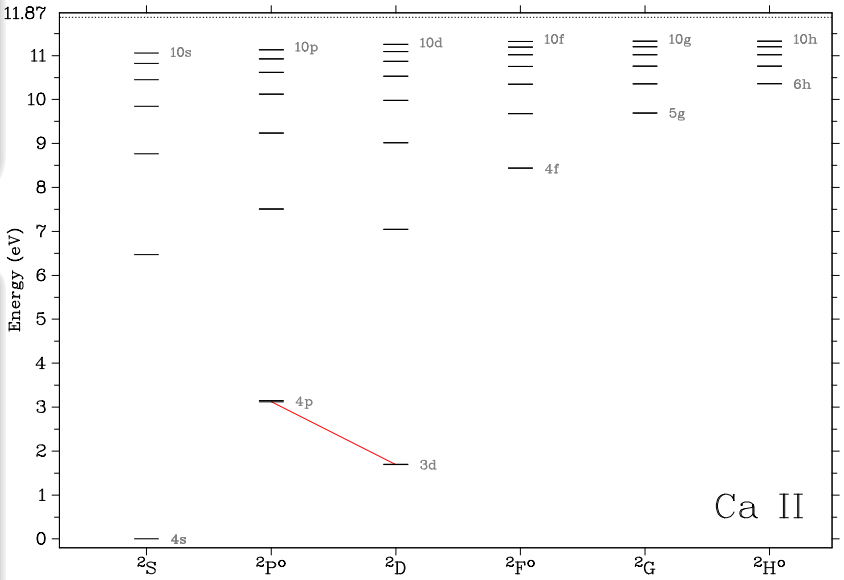




Results for cool giant an supergiant stars

MULTI computes the **departure coefficients** ($b_i = n_i/n_i^*$) and the **NLTE/LTE equivalent widths** (W/W^*)

Atmospherical parameters for galactic stars

- $3500 \leq T_{\rm eff} \leq 5500$ K with a step of 250 K
- $0.5 \leq \log g \leq 2.0$ with a step of 0.5 dex
- $-4.0 \leq$ [Fe/H] $\leq +0.5$ with a step of 0.5 dex in [-4.0, -1] and 0.25 in [-1.0,+0.5]

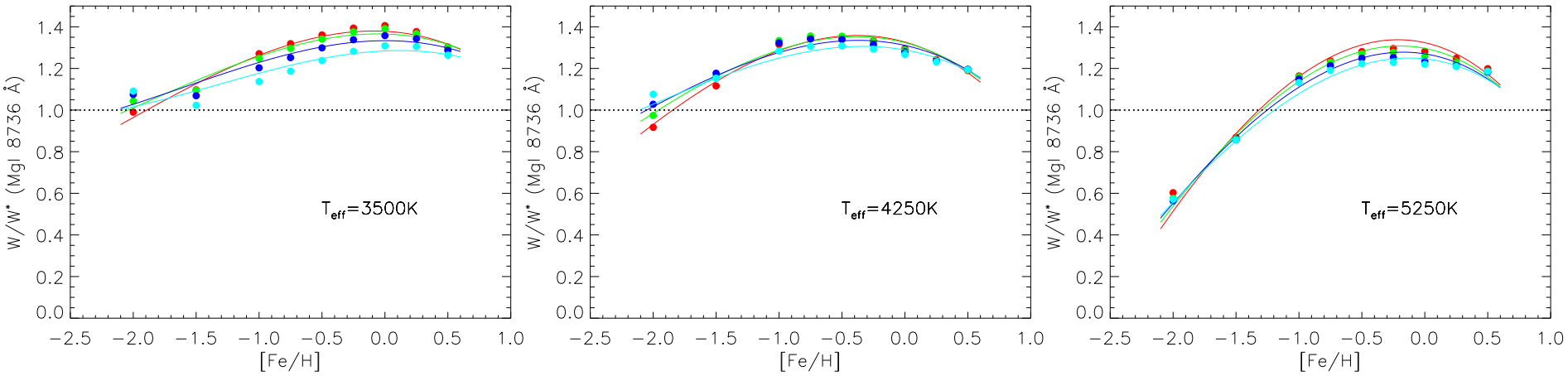
Model atmosphere				Mg I 8736 Å	CaII 8498 Å
$T_{\rm eff}$	$\log g$	[Fe/H]	[α/Fe]	W/W^*	W/W^*
5000	1	+0.50	0.0	1.18	0.97
5000	1	+0.00	0.0	1.27	0.97
5000	1	-0.50	0.2	1.30	0.98
5000	1	-1.00	0.4	1.21	0.99
5000	1	-2.00	0.4	0.67	1.04
⋮	⋮	⋮	⋮	⋮	⋮

(Merle et al., 2011) and CDS J/MNRAS/418/863

+ third order polynomial fits as a function of atmospheric parameters

The NLTE effects on the MgI 8736 Å line

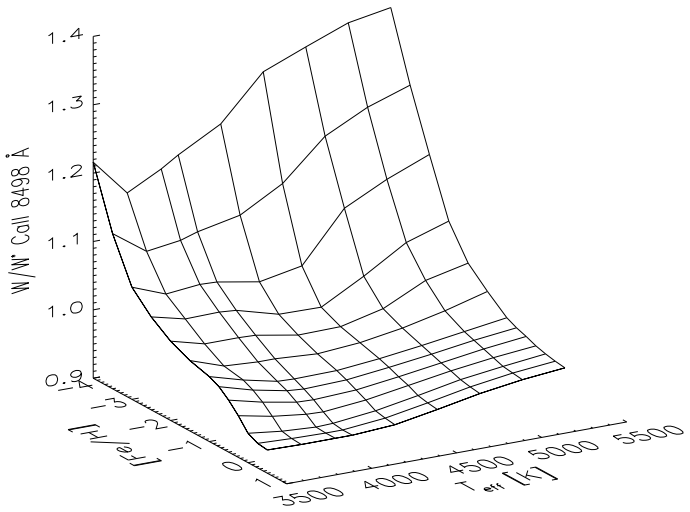
$\log g = 0.5$, $\log g = 1.0$, $\log g = 1.5$ et $\log g = 2.0$ Merle et al. (2011)

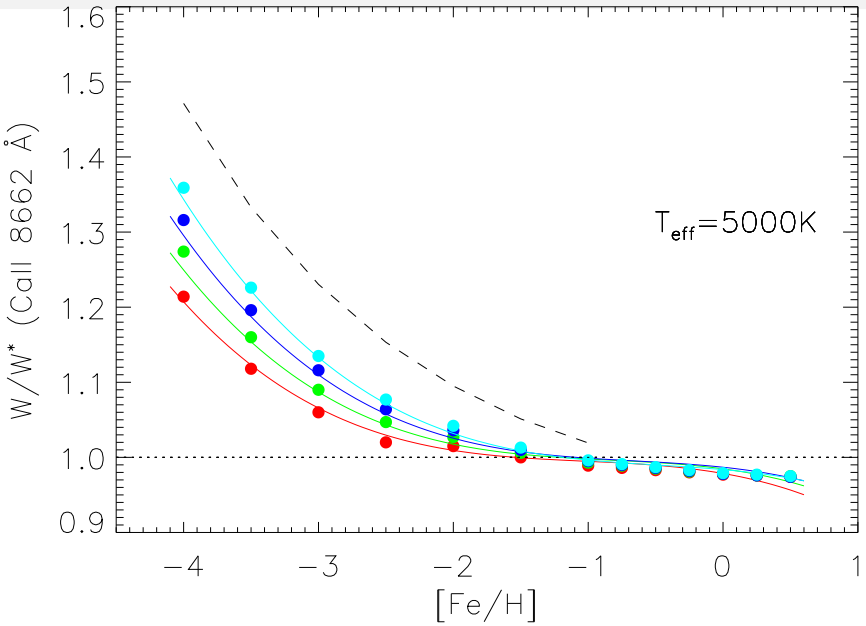


Effect on the W/W^*

- W/W^* mainly $> 1 \rightarrow \Delta[\mathrm{Mg/H}] = [\mathrm{Mg/H}]_{\mathrm{NLTE}} - [\mathrm{Mg/H}]_{\mathrm{LTE}} < 0$
- Mg abundance mainly overestimated in LTE

The NLTE effects on the IR CaII triplet (CaT)





Why this behaviour?

- $S_{CaT} \simeq \frac{b_{4p}}{b_{3d}} B(T)$
- if $\frac{b_{4p}}{b_{3d}} > 1$ then NLTE line is weaker and $W < W^* \rightarrow \Delta[\mathrm{Ca/H}] > 0$ and Ca abundance is underestimated in LTE.
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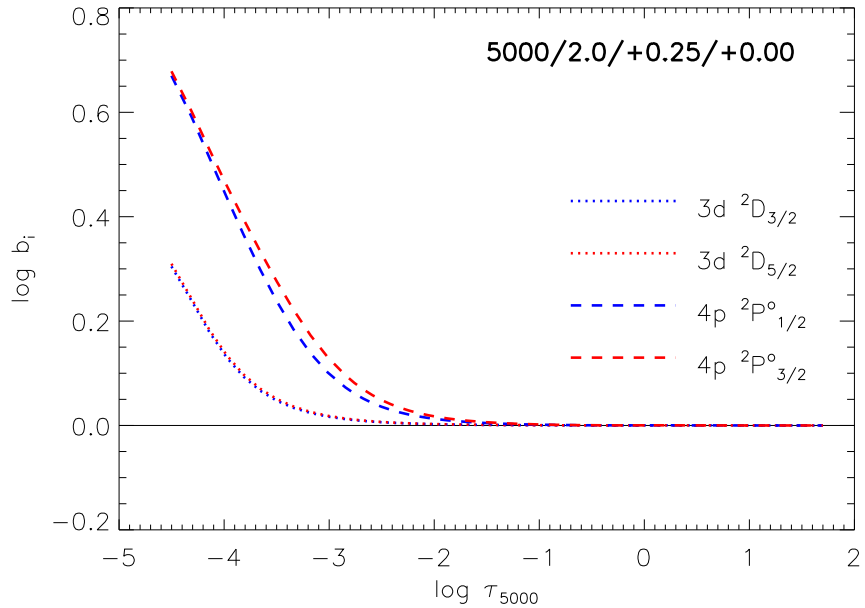

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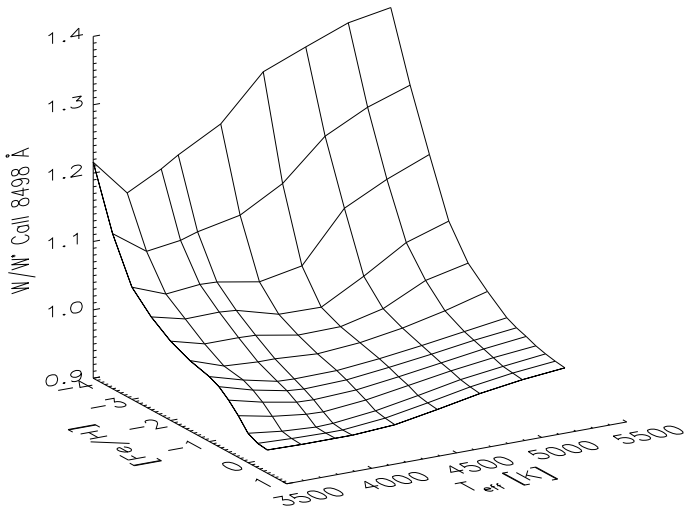

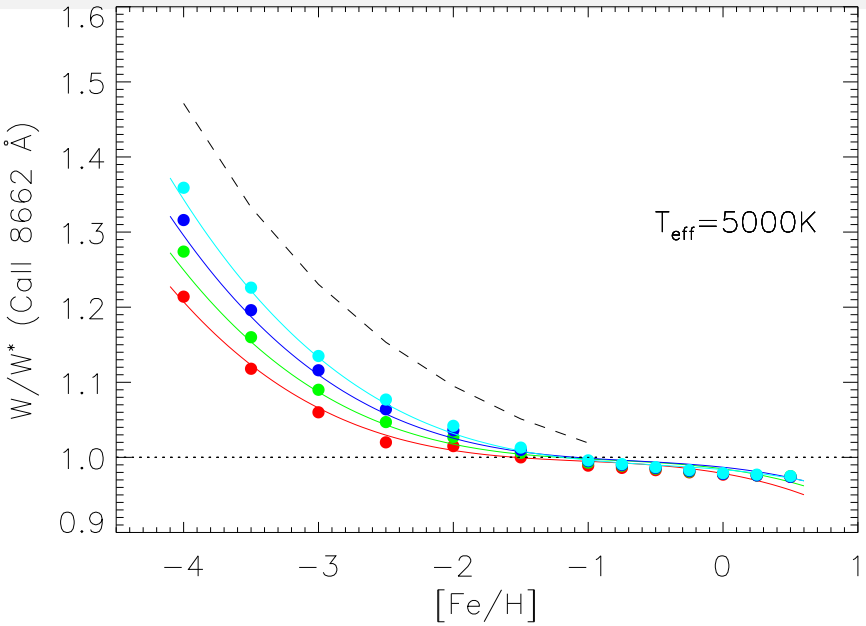

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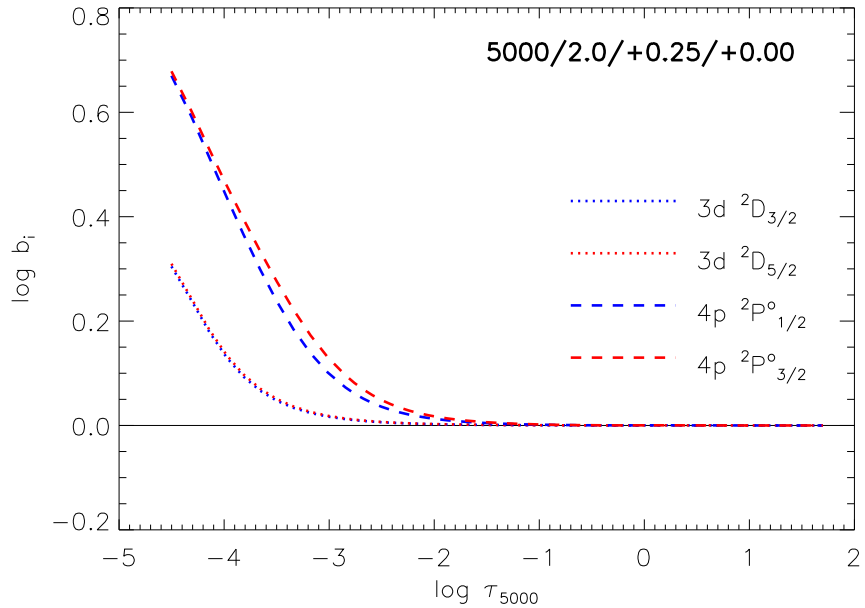

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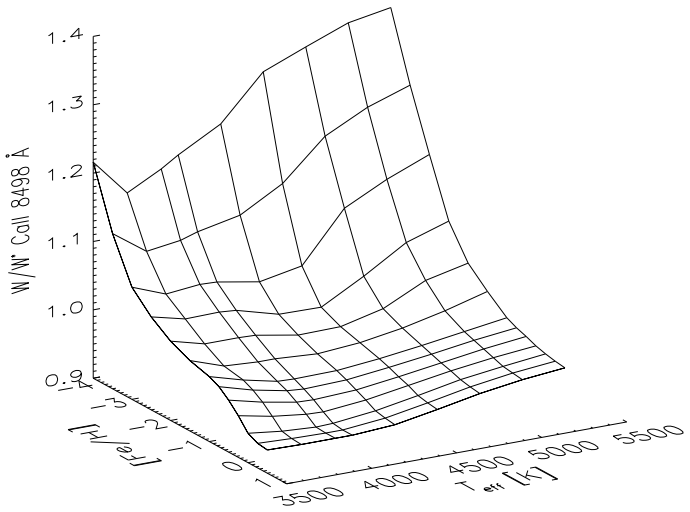

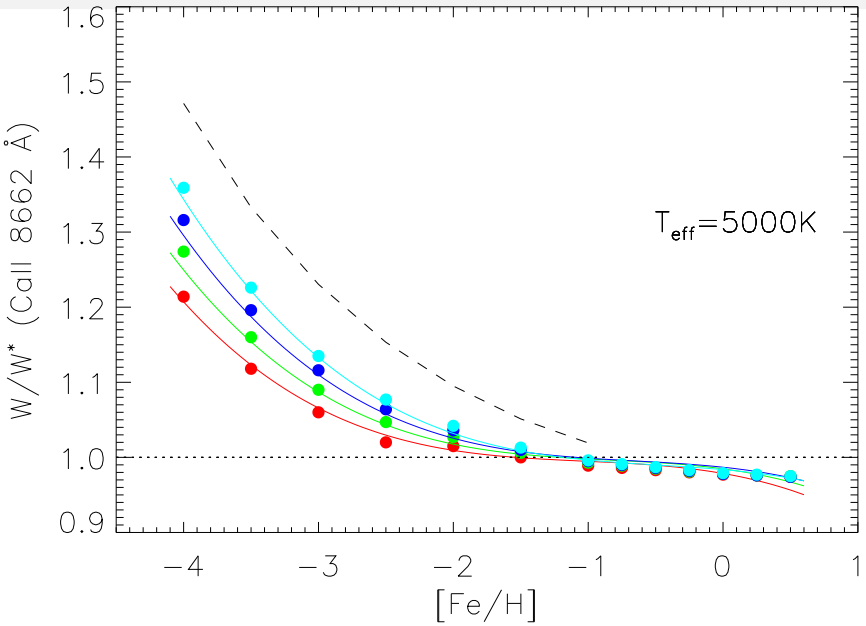

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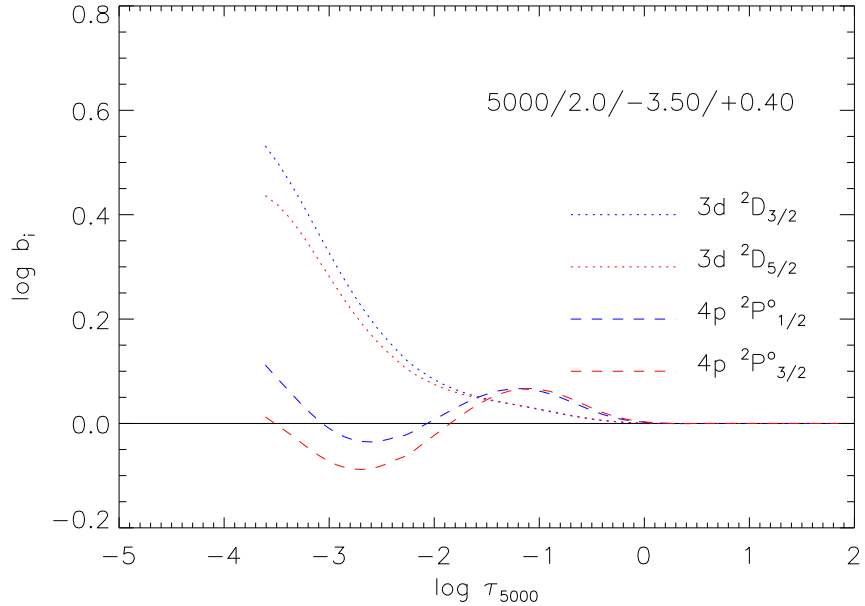

To resume

How to improve abundance of α-elements of stellar populations?

NLTE corrections

- W/W^* available for the *Gaia* lines (but not only) for a detailed grid of giant and supergiant model atmospheres
  (**Merle et al. 2011, MNRAS, 418, 863 and on VizieR, CDS**)
- Polynomial fit of the W/W^* for the *Gaia* lines (only) as a function of atmospheric parameters ($T_{\rm eff}, \log g$ and [Fe/H])

"It is always appropriate to provide the LTE results for comparison purposes, but it is unwise to ignore the available non-LTE calculations when presenting the final abundance values."

Asplund (2005)

In the era of automated LTE EW synthesis to determine stellar chemical composition...

... computed W/W^* can be easily applied to the measured EW to determine NLTE abundances!

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