TOWARDS AN ABUNDANCE DETERMINATION FOR THE OB STARS IN THE GAUDI DATABASE

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Abstract: A knowledge of the chemical composition of the OB stars observed during the COROT asteroseismology program is needed for further theoretical modelling. We have started a project that aims at deriving the stellar abundances of all the OB stars with high-resolution spectra available in the GAUDI database. Here we present the methodology and first results for some β Cephei stars observed as part of our long-term spectroscopic monitoring.

Rationale of the project:

A precise knowledge of the physical parameters of the early-type stars observed during the COROT mission is a prerequisite for further theoretical modelling (in particular the metal content, as it is one of the key factors controlling the incidence of pulsational instabilities). The vast majority of all the OB stars in the GAUDI database lack reliable estimates of their fundamental parameters. The goal of this project is to remedy to this situation, with particular attention devoted to the determination of their detailed chemical composition (and not only a global estimate of the metallicity).

Here we present the methodology which we first applied to some β Cephei stars with physical parameters already known from prior studies. The abundances are derived from spectral synthesis techniques and with a full NLTE treatment using the line formation codes DETAIL/SURFACE and line-blanketed Kurucz atmospheric models. At this stage, the following elements are considered: C, N, O, Mg, Al, Si and S. More than 500 spectral lines can be synthetized in the visible domain.

Determination of the fundamental parameters:

- **Effective temperature**: derived from theoretical calibrations between the Si II/III/IV line ratios and the temperature (see Fig.1).

- **Surface gravity**: derived from fitting the collisionally-broadened wings of the Balmer lines (see Fig.2).

- **Microturbulence**: derived from requiring the individual abundances given by the O II lines to be independent of the line strength (see Fig.3).

Because the line profiles are sensitive to all these parameters, an iterative procedure must be used.

Derivation of the abundances and first results:

- Once the physical parameters above are determined, a curve-of-growth abundance analysis is carried out by matching the observed and predicted equivalent widths of a set of carefully-selected, unblended spectral lines.

- The vsini is finally derived by minimizing the residuals between the rotationally broadened synthetic line profiles of some weak O II lines and the observed ones.

- Figure 4 shows a comparison between the observed and final synthetic spectrum for β CMa (B1 III). The following results have been obtained and illustrate the typical accuracy achievable by this method (the abundances are solar within the errors, e.g., Daflon & Cunha 2004, ApJ, 617, 1115):

T_{eff}=24000 +/- 1000 K, log g=3.5 +/- 0.1 [cgs], ξ=14 +/- 3 km s^{-1}, vsini=23 +/- 2 km s^{-1}
log ε(C) = 8.13 +/- 0.12 dex, log ε(N) = 7.59 +/- 0.14 dex
log ε(O) = 8.62 +/- 0.18 dex, log ε(Mg) = 7.30 +/- 0.18 dex
log ε(Al) = 6.00 +/- 0.15 dex, log ε(Si) = 7.17 +/- 0.23 dex
log ε(S) = 7.14 +/- 0.25 dex (by convention, log ε[H]=12)

The mean NLTE corrections are systematically negative, but never exceed 0.17 dex.

Future developments:

- Constructing an iron model atom to derive NLTE abundances from the weak Fe III lines.
- Carrying out the same calculations, but with a line formation code taking into account the stellar wind (FASTWIND; Puls et al. 2005, A&A, 435, 669).
- Developing (semi-)automatized techniques to cope with the large number of OB stars in the GAUDI database (about 200).

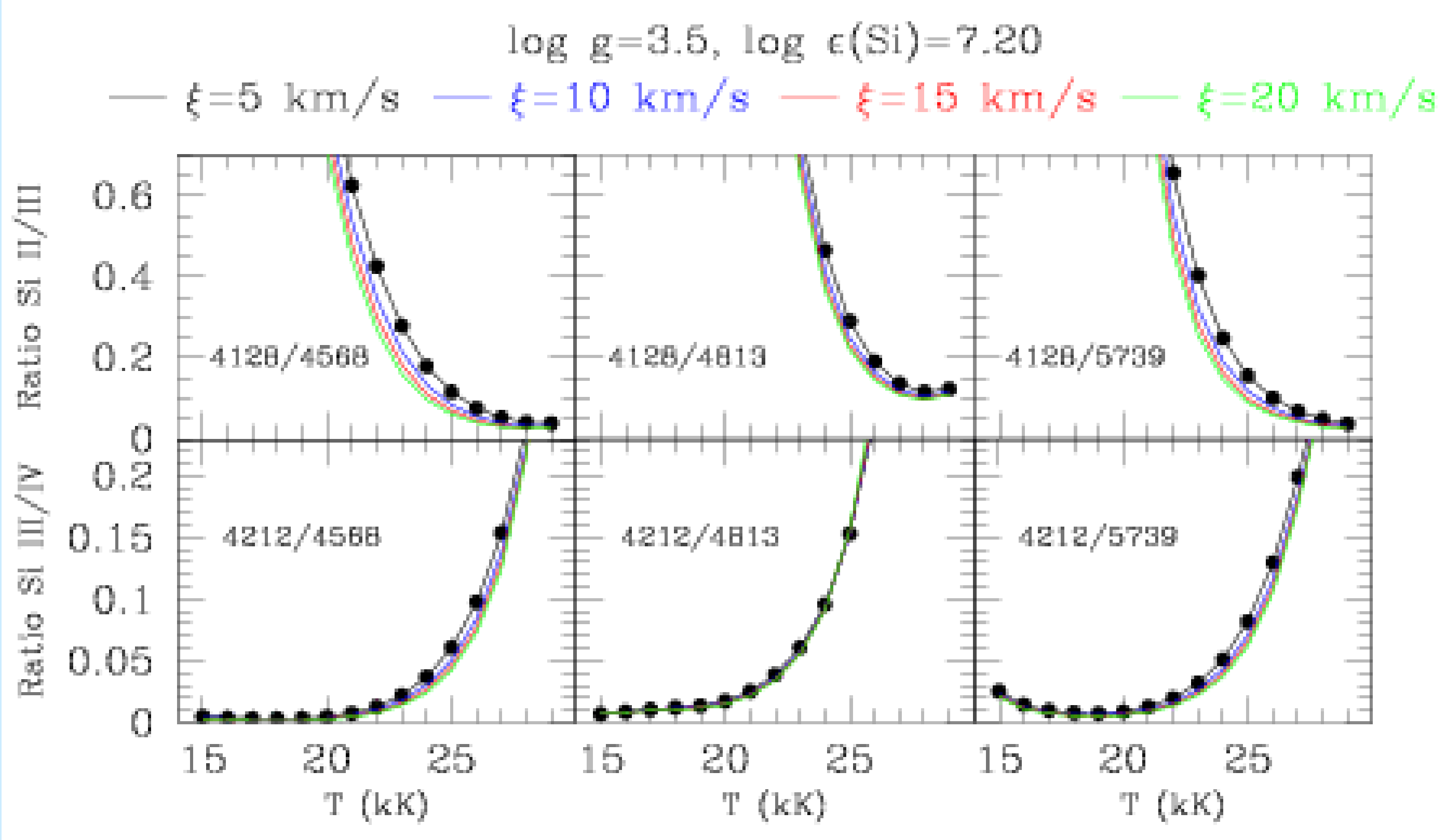

Fig.1 – Examples of calibrations between various silicon line ratios and the temperature, as a function of the microturbulence ξ.

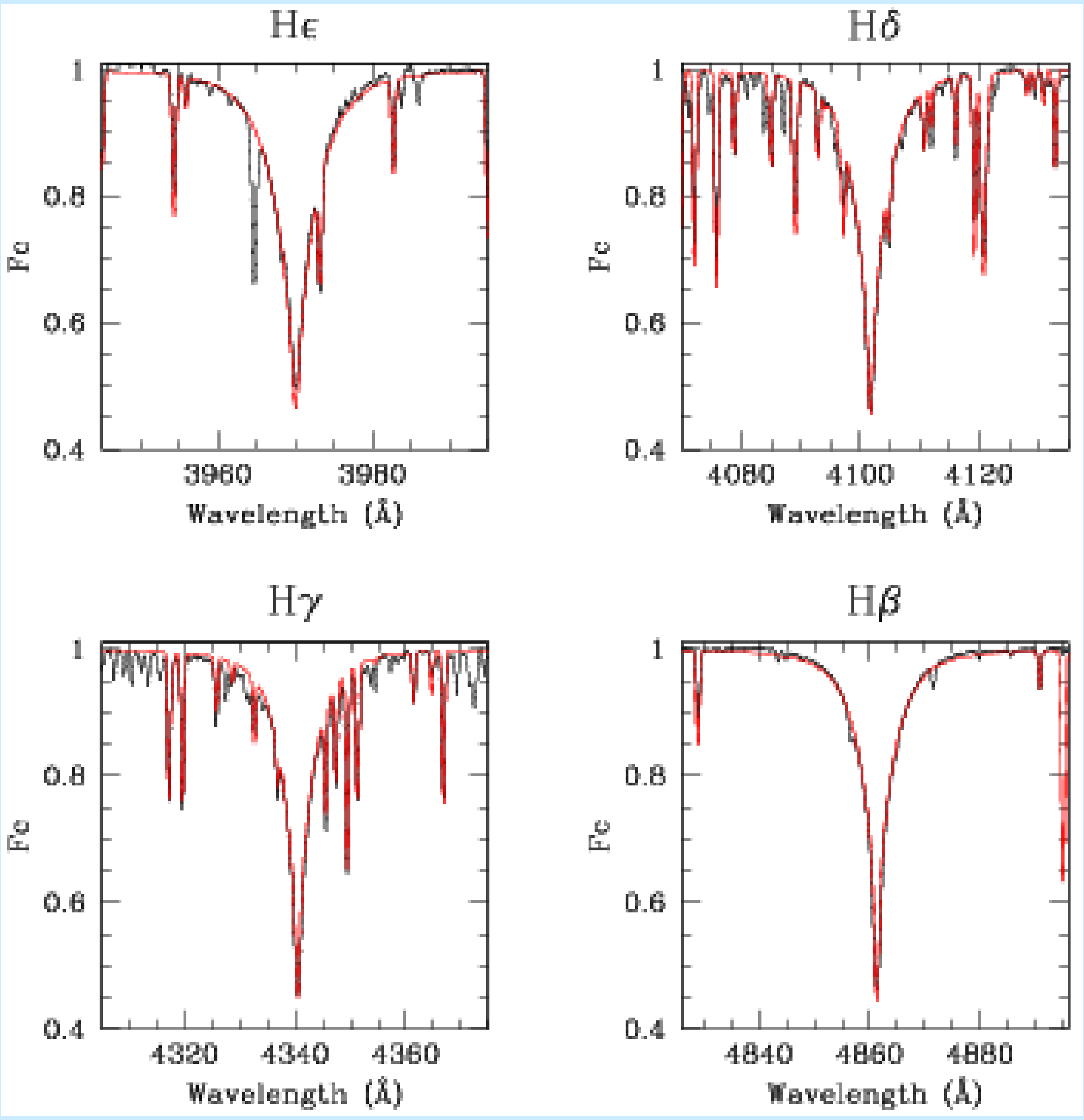

Fig.2 – Synthetic (*red*) and observed (*black*) spectra of β CMa for the regions encompassing the Balmer lines (T_{eff}=24000 K and log g=3.5).

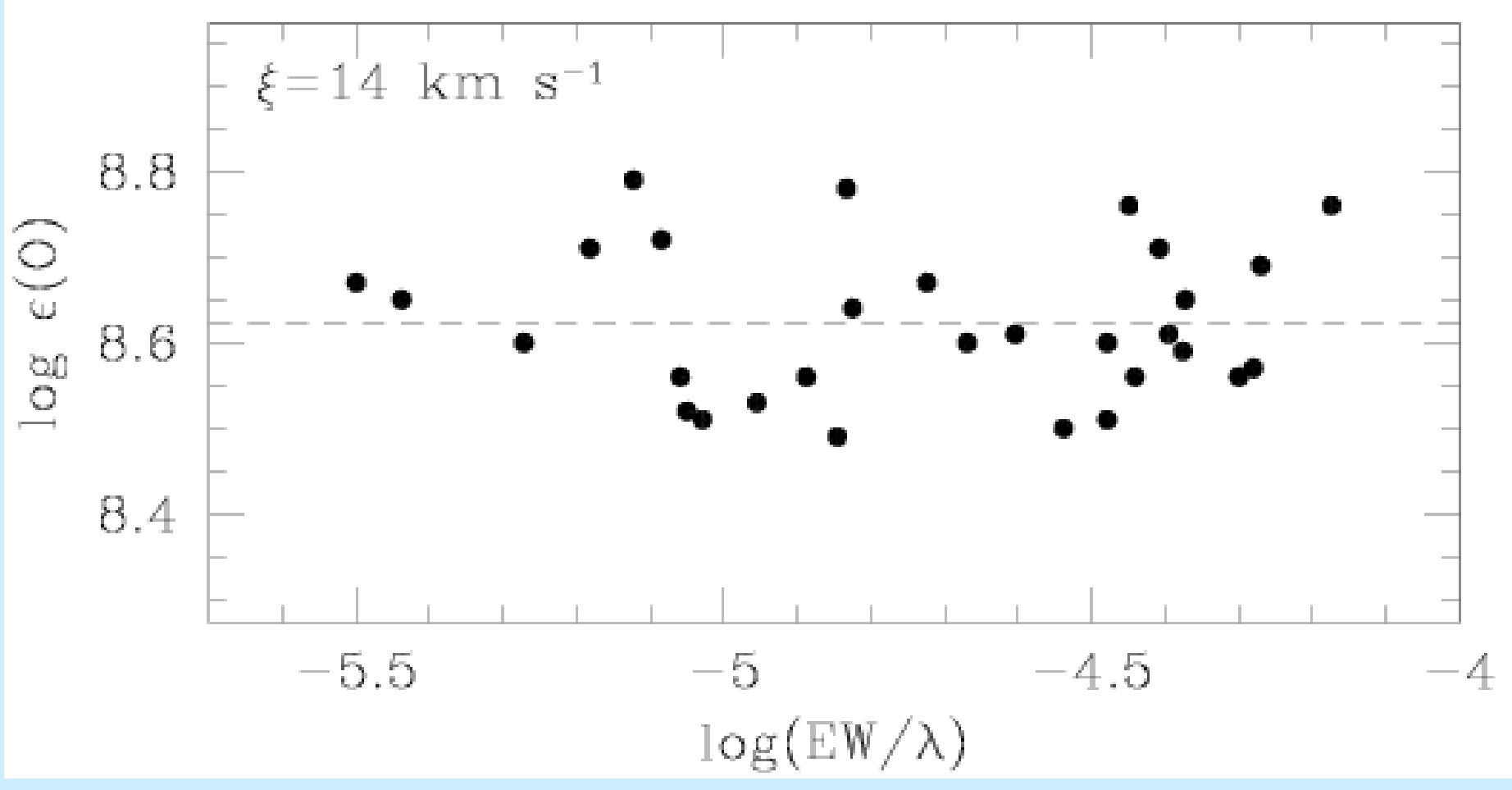

Fig.3 – Abundances yielded by the individual O II lines, as a function of the (reduced) equivalent width for β CMa.

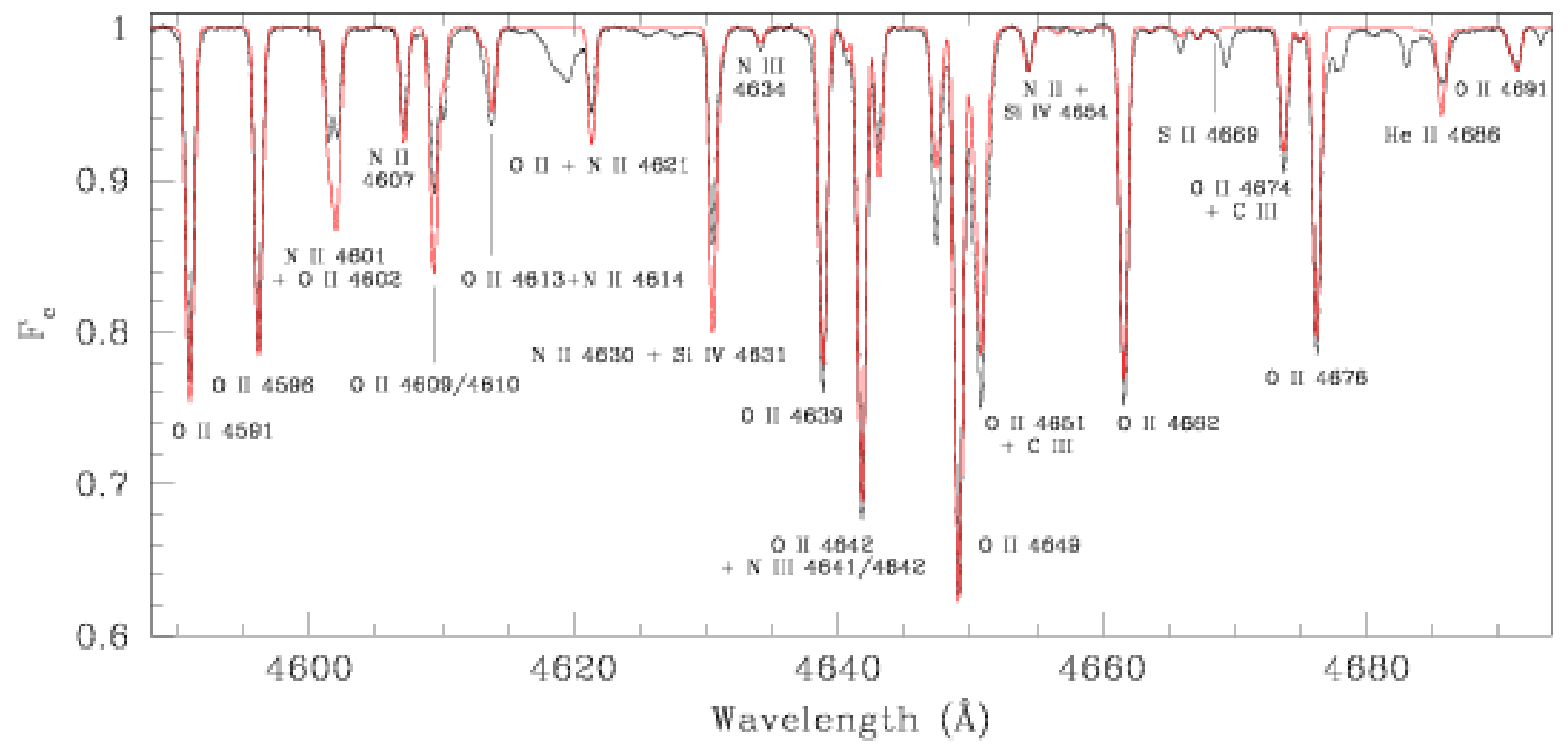

Fig.4 – Comparison for the spectral range 4588-4694 Å between the synthetic (*red*) and observed (*black*) spectra of β CMa. The synthetic spectrum has been broadened by a rotational profile with vsini=23 km s^{-1}.