α-ENHANCEMENT IN THIN AND THICK DISC STARS: AN ATLAS OF SYNTHETIC SPECTRA

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ABSTRACT

We present a new collection of synthetic spectra finalized at the derivation of information about the enhancement of α-process elements in the atmospheres of F-G-K stars. The spectra are computed at high resolution from fully consistent models and Opacity Distribution Functions (ODFs) for [α/Fe]= $+0.0$ and $+0.4$. Comparisons with observed spectra at $R \approx 2000$ from the STELIB library are illustrated. Synthetic photometry in the Gaia photometric system, once the filter characteristics will be definitively assessed, could be computed and analyzed for disentangling α-enhanced stars from solar scaled chemical abundance ones.

Key words: Stars: atmospheres; Synthetic spectra; Abundances; α-enhancement.

1. INTRODUCTION

In the study of thin and thick disc stars the abundance and kinematical analyses of stars characterized by the so-called α-enhancement phenomenon are of great relevance, in particular, to get insights into the role of SN I and SN II in the chemical enrichment of individual stellar populations.

In general, detailed high resolution analysis of individual stars based on synthetic spectra is used to tackle the problem of determining individual element abundances. This kind of approach may be complemented by a statistical one based on synthetic photometry in wavelength ranges representative of relevant elemental species. For instance, Franchini et al. (2004a,b) proposed selected combinations of Lick/IDS indices capable of singling out α-enhanced stars without requiring previous knowledge of their main atmospheric parameters i.e., stellar effective temperature, surface gravity, and metallicity [Fe/H].

The purpose of this contribution is to present to the Gaia community a collection of synthetic spectra finalized at the analysis of the α-elements enhancement phenomenon in the atmosphere of F-G-K stars.

2. THE GRID OF SYNTHETIC SPECTRA

Our grid comprises 1320 synthetic spectra computed with wavelength sampling of 0.005 nm, rotational velocity of 0 km s^{-1} and 2 km s^{-1} of microturbulent velocity, in the wavelength range 400-650 nm. The spectra were obtained by using the stellar spectral synthesis program SPECTRUM (Gray & Corbally 1994) and ODFNEW models by Castelli & Kurucz (2003). The grid covers effective temperatures from 4250 to 7000 K, at 250 K step, surface gravities from 0.5 to 5.0 dex, at 0.5 step, and [Fe/H] from -2.0 to $+0.50$.

Solar scaled abundances and enhanced α over iron ratios were considered (SSA and NSSA grids, respectively). The SSA grid is based on Grevesse & Sauval (1998) solar abundances, while the NSSA grid assumes [α/Fe]= $+0.4$ where the α-elements considered are O, Ne, Mg, Si, S, Ar, Ca, and Ti.

Figure 1 shows the dependency of synthetic spectra on the different atmospheric parameters, i.e., [α/Fe], log g, [Fe/H], and $T_{\rm eff}$. This figure can be compared with the analogous one, referring to the same values for the atmospheric parameters but for [α/Fe], in Tautavaišienė & Edvardsson (2002); there is a general agreement, even if we use [α/Fe] $= +0.4$ instead of [α/Fe] $= +0.3$, with two major exceptions:

- the flux ratio of the NSSA spectrum over the SSA one computed with the same $T_{\rm eff}$, log g, and [Fe/H] parameter values (Figure 1, panel a) shows significant differences mainly in the region of CH and Mg I while Tautavaišienė & Edvardsson (2002) find significant differences also at about 4600 and 5100 Å in correspondence with C_2 features;
- the effect of changing [Fe/H] shown in panel c is slightly smaller than that obtained by Tautavaišienė & Edvardsson (2002).

3. TESTS WITH OBSERVATIONAL DATA

The observational data set represented by the STELIB collection is used for testing the suitability of our syn-

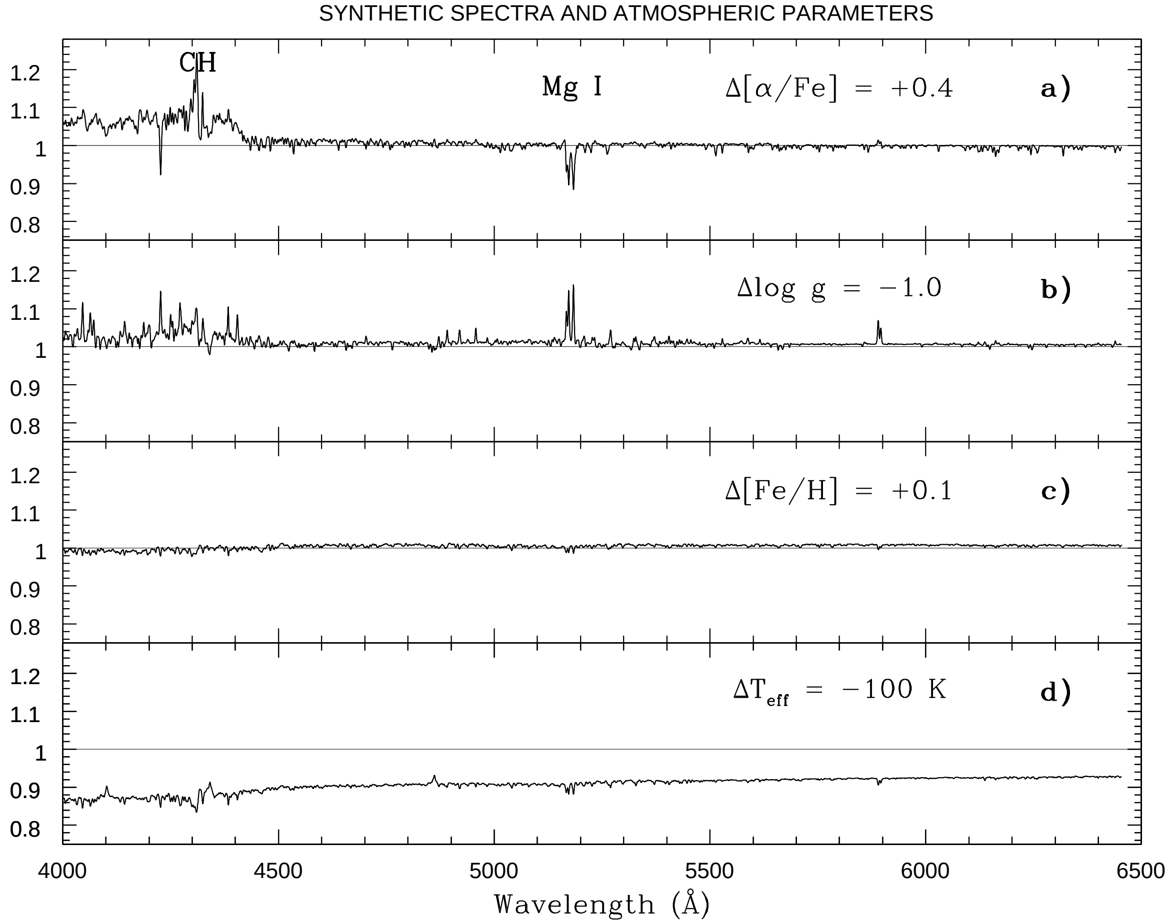

Figure 1. Flux ratios of synthetic spectra computed with different atmospheric parameters plotted versus wavelength. The reference normalizing spectrum has $T_{\rm eff}$ = 5500 K, log g = 4.0, [Fe/H]= −0.4 and [α/Fe]= +0.0. The following variations are considered: [Δα/Fe] =+0.4 (panel **a**), *Δ log g = −1.0 dex (panel* **b**), *Δ[Fe/H]= +0.1 dex (panel* **c**), *and Δ$T_{\rm eff}$ = −100 K (panel* **d**).

thetic spectra in reproducing the observed features. The SSA and NSSA spectra can be successfully compared with those of F-G-K stars from the STELIB spectroscopic stellar library (Le Borgne et al. 2003) after degrading and resampling the synthetic spectra at the resolution and wavelength sampling of the observations.

In order to extract from our grids the spectrum appropriate for matching a given observed one, we need to know the values of ALL the atmospheric parameters pertaining to the star, i.e., stellar effective temperature, surface gravity, metallicity [Fe/H], and α-elements content. While the first three atmospheric parameter values can be obtained from STELIB itself, the [α/Fe] abundance need to be inferred. To select those stars which require the use of SSA or NSSA spectra, respectively, we applied the method presented by Franchini et al. (2003, 2004a,b), based on the use of a suitable set of Lick/IDS indices.

In Franchini et al. (2004a) we introduced four combinations of indices, namely NaD vs Ca4227, NaD vs Mg_2, NaD vs Mgb, and NaD vs CaMg=(0.125×Ca4227 + Mg_2), which allow us to identify different loci in index-index diagrams representative of SSA and NSSA points irrespectively of effective temperatures, surface gravities and iron abundance. It is then possible to mark a STELIB star either as 'NSSA' or 'SSA', without previous knowledge of any of its atmospheric parameter values, by looking at its position in these diagrams with respect to appropriate boundary lines. Hence the observations, when referring to a star marked as α-enhanced, have to be compared with synthetic spectra extracted from the NSSA grid. Thus we compute the synthetic spectrum with the atmospheric parameters from STELIB either from the SSA or from the NSSA grid, according to the results of the classification.

Examples of the comparison between observed and computed spectra are given in Figures 2 and 3 for HD 65583, a G8V star with the following atmospheric parameters from STELIB: $T_{\rm eff}$ = 5295 K, log g = 4.64, and [Fe/H] = −0.66. This star has been detected as α-enhanced by Franchini et al. (2003) method, therefore the synthetic spectra from the NSSA grid are used for comparison in Figure 2. The variations in atmospheric parameters have the same values as in Figure 1. The result is that the case corresponding to the parameters listed in STELIB provides the overall better description of the

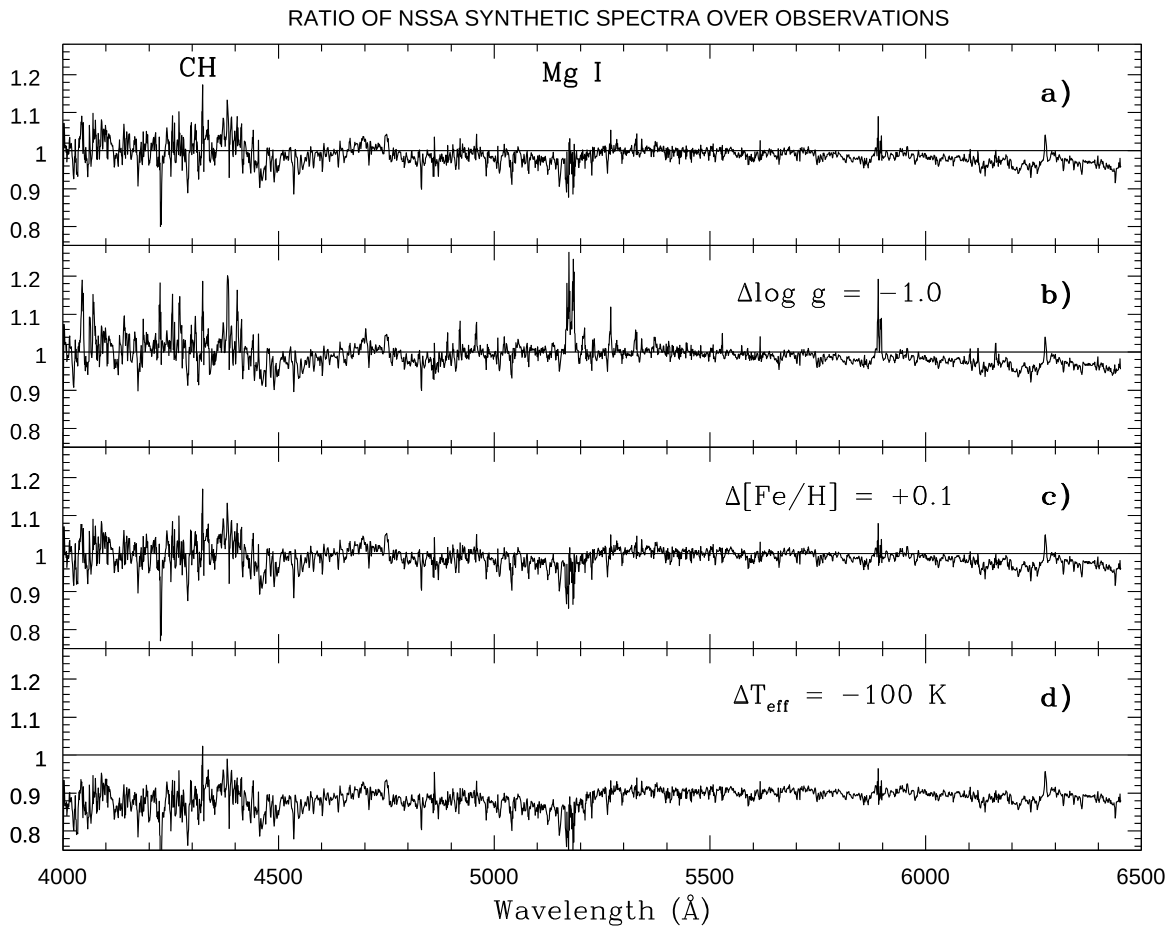

Figure 2. Flux ratios of NSSA synthetic spectra over the observed one (the observations refer to the G8V star HD 65583). The synthetic spectrum computed with $T_{\rm eff}$ = 5295 K, log g = 4.64, [Fe/H]= −0.66 and [α/Fe]= +0.4 is used in panel **a***, while the synthetic spectra considered in the other panels are computed with the same variations in atmospheric parameters as in the corresponding panels of Figure 1.*

data, even though a small difference in [Fe/H] cannot be excluded. Figure 3 shows the same kind of comparison but using the SSA grid: here the synthetic spectra with solar scaled abundances are less suitable for the description of the observations in the relevant CH and MgI regions, thus confirming the detection of this star as α-enhanced.

4. CONCLUSION

The effects of variations of atmospheric parameters, in particular of [α/Fe], on synthetic spectra are clearly depicted in Figure 1. Figures 2 and 3 illustrate the reliability of our grids of synthetic spectra to interpret the observed spectra. In particular, spectral windows covering the CH and Mg I features provide significant information about the enhancement of α-process elements in stellar atmospheres, thus we plan to compute, in the near future, Gaia synthetic photometry based on our collection of spectra looking for a tool to disentangle NSSA from SSA stars.

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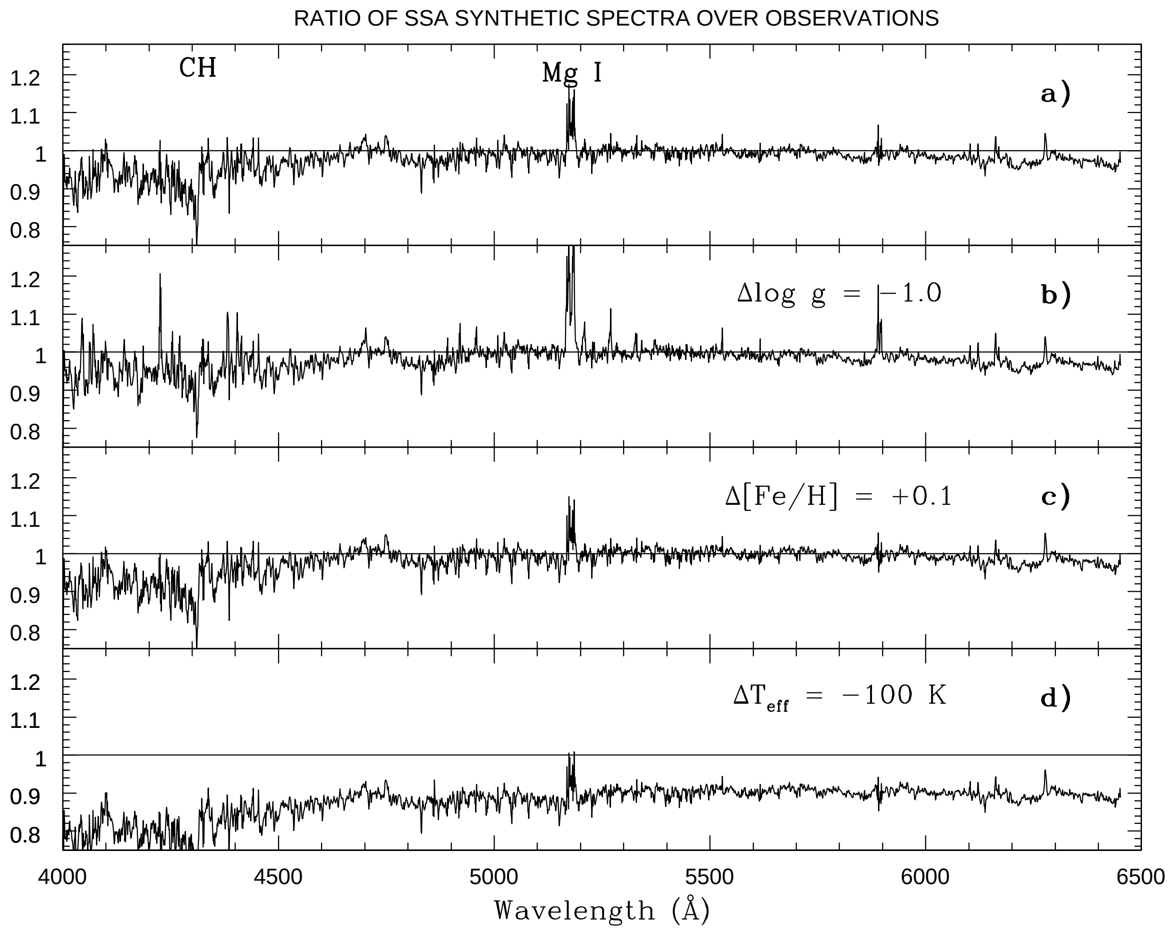

Figure 3. Flux ratios of SSA synthetic spectra over the observed one (the observations refer to the G8V star HD 65583). The synthetic spectrum computed with $T_{\rm eff}$ = 5295 K, log g = 4.64, [Fe/H]= −0.66 and [α/Fe]= +0.0 is used in panel **a**, *while the synthetic spectra considered in the other panels are computed with the same variations in atmospheric parameters as in the corresponding panels of Figure 1.*

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