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Erratum

The effects of new Na I D line profiles in cool atmospheres

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Due to an error in the unit conversion of the computed profiles, the results of Sect. 3 have to be corrected. Section 3 should read as follows.

Figure 1 displays synthetic spectra for $T_{\rm eff}$ = 1100–3000 K and $\log(g) = 4.5$ at a reduced resolution of 10 000 around the sodium resonance doublet. The original calculated resolution of the synthetic spectra is 3×10^5. All wavelengths are given in vacuum. In Fig. 1, for effective temperatures of 1100 K, 1500 K, and 2000 K, large differences between the different model types are obvious, especially "impact" versus "modern1-3". At $T_{\rm eff}$ = 2500 K and 3000 K, molecular bands, such as TiO, VO, CaH, and FeH, become predominant and overwhelm the effect of the different line profiles on the emitted spectrum. A close up of the sodium doublet of Fig. 1 is shown in Fig. 2. It shows the differences in more detail at the full computed resolution.

The contribution of sodium broadened by neutral hydrogen (modern2) is most visible in the near wings at higher effective temperatures, $T_{\rm eff}$ = 2000–3000 K, as predicted by Johnas et al. (2006) and depicted in Fig. 2. Under these atmospheric conditions, atomic hydrogen becomes the most prominent species at the optical depths where the line wing forms. There are differences[1] of up to 6.2%, −7%, and −3.4% for $T_{\rm eff}$ = 3000 K, 2500 K, and 2000 K between the modern1 and modern2 spectra for the sodium D lines. At lower effective temperatures, the differences are smaller due to the decreasing concentration of atomic hydrogen: For $T_{\rm eff}$ = 1500 K the relative change in flux is at the most +0.35% and for $T_{\rm eff}$ =1100 K, in the near line wings the relative change decreases from +0.5% to −2%. Very close to each of the two central wavelengths, the relative change increases to 2.5% at $T_{\rm eff}$ = 1100 K.

When comparing the impact spectra with modern2 spectra, the differences in the near wing regions are between +25% and −150% at $T_{\rm eff}$ = 3000 K. The change is even stronger at $T_{\rm eff}$ = 2500 K, between +50% and −290% in the near wings. The strong decrease appears towards the line centers whereas at the line centers the relative change is only approximately 10% and 20% for $T_{\rm eff}$ = 3000 K and 2500 K respectively. For lower effective temperatures starting at $T_{\rm eff}$ = 2000 K, the influence in the line wings (at 5800 Å) is even greater, decreasing from 87% to 76% at $T_{\rm eff}$ = 1500 K and 63% at $T_{\rm eff}$ = 1100 K. The near wing regions are affected by up to 70%, 57% and 45% respectively for these effective temperatures. Towards the absorption cores the relative changes of the flux decreases from the differences in the near wings to ≈–15%, 5%, and 10%. These strong differences are expected, however, as there are substantial differences between the impact and modern1–3 line profiles.

Due to the similar characteristics of the modern3 and modern2 spectra, the difference between the two is at the most between +1% and –0.7%, 0% and –7%, +0.9% and –4.2%, 1.35% and –0.4%, and +3.5% and –2.7% at effective temperatures from 3000 K to 1100 K. These changes describe the influence of the two different descriptions of the perturbations with helium. Differences between the modern1 and modern3 spectra are again noticeable in the entire effective temperature range. Their maximum values are +6.5%, between +1.3% and −1.7%, between +0.7% and −1%, between +0.6% and −0.9% and +0.9% and −1.3% for the effective temperatures from 3000 K to 1100 K. Following the discussion above, comparing with the spectra of the impact setup, the differences between the impact and modern3 spectra are again of the same order of magnitude and the changes are increased in the wings towards the lower effective temperatures as can be seen in Fig. 1.

With the flux contribution function $\mathscr{C}_F$ as introduced in Magain (1986) and Fuhrmeister et al. (2006) and applied in Johnas et al. (2006), the differences around 5891 Å seen in Figs. 1 and 2 between the different model types can be interpreted. The maximum of $\mathscr{C}_F$ indicates the layers where the line forms in the atmosphere at a specific wavelength. The wavelength 5891 Å has been chosen to represent the near wing region in which the changes in the setups are significant. For each effective temperature slightly different locations of the line forming region in the atmosphere for each model type are found, as shown in Fig. 3. This is one aspect for the differences in the emergent flux of the synthetic spectra.

[1] If not otherwise mentioned, the comparison refers to a wavelength range between 5850 Å and 5950 Å.

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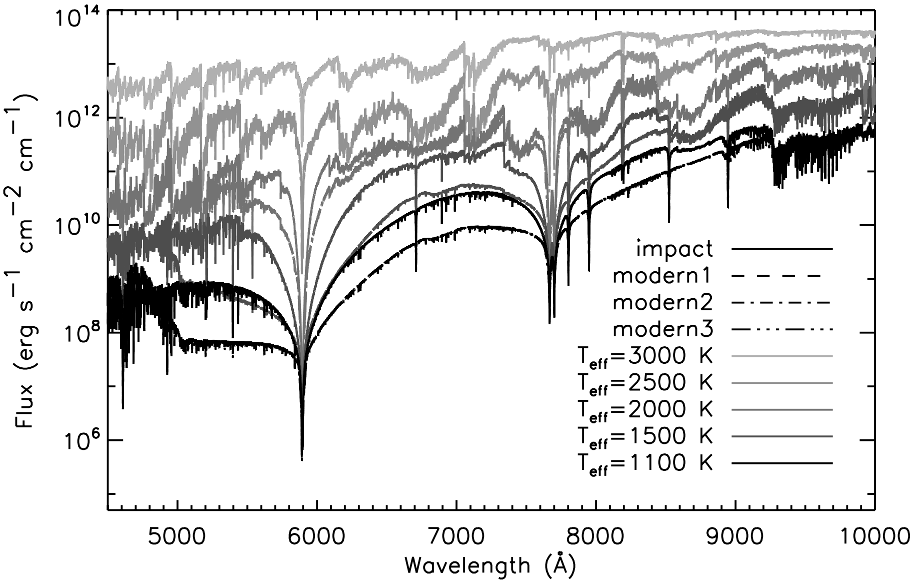

Fig. 1. Smoothed synthetic spectra with a resolution of 10 000 for models with $T_{\rm eff}$ = 1100 K to 3000 K displaying the differences between the four different line profile setups.

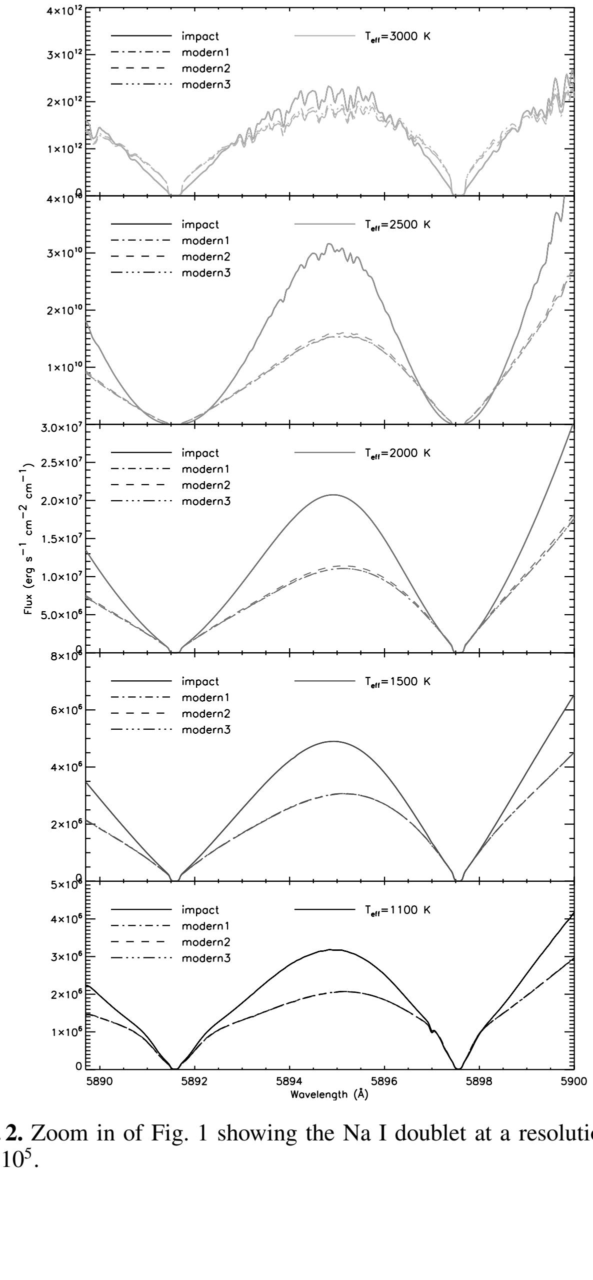

Fig. 2. Zoom in of Fig. 1 showing the Na I doublet at a resolution of 3×10^5.

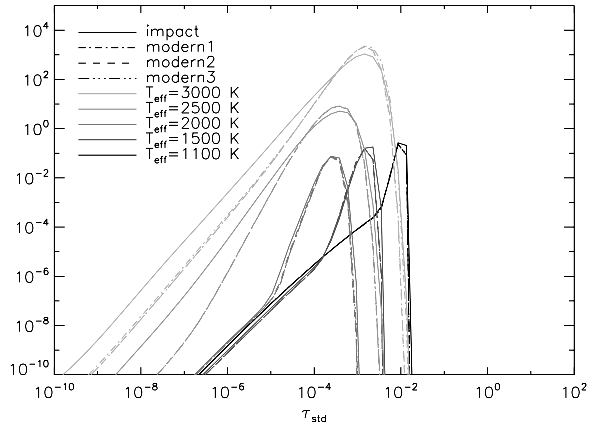

Fig. 3. Contribution function at 5891 Å for effective temperatures from 3000 K to 1100 K for the four line profile setups.

Further analyses of the flux contribution function and the gas pressure of each model type for each effective temperature have shown that the locations of the maxima of the flux contribution functions are consistent with the theoretical predictions. Moving closer to the line core, the maxima are positioned at higher and hence cooler regions of the atmosphere. On the other hand, moving further into the line wings of the Na I D_2 absorption line, the flux contribution originates in deeper and hotter layers of the atmosphere.

The second sentence of the conclusion section should be replaced by: the changes made in the intrinsic line profiles of the modern2 and modern3 setup concern the data of the near wings. Their influence in the synthetic spectra depends on the effective temperature.

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