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Physical requirements for modeling stellar atmospheres according to the different spectral features observed

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Abstract. Only stellar atmosphere models that span a wide range of optical depth can allow a correct treatment of radiative transfer at all the frequencies of the spectrum.

Keywords. Stellar atmosphere models, synthetic spectra, radiative transfer

1. The optical depth of formation of different spectral features

Due to the enormous difference among the opacities at the different frequencies of a stellar atmosphere's spectrum, the condition $10^{-3} \leqslant \tau_\nu \leqslant 10^3$, which sets the limits for effective radiative transfer frequency by frequency, will hold at very different depths in the atmosphere. The most opaque spectral features, *i.e.* the Lyman continuum and lines, form at very shallow mean optical depths, corresponding to superficial layers that the models currently in use cannot cover. (See Fig. 1.)

2. Comparison with Kurucz's ATLAS9 models

Our laboratory models have been computed by taking into account a thickness such as to include the effective formation regions for all those frequencies that are necessary both to account for a correct treatment of the energy balance and to yield a good synthesis of the spectral features formed in the outermost regions. On the contrary, Kurucz's models cannot treat properly the physical behavior of the atmosphere in the outermost layers, *i.e.* $\tau_{Ross} < 10^{-4}$. The emergent spectra of the Sun and Vega are compared in Fig. 2.

3. Conclusions

In order to obtain relatively correct stellar spectra in the far UV region (visible for galaxies with intermediate and high z), it is compulsory to compute models that cover a wide range in optical depth, up to τ_{Ross} of order of about 10^{-10} for hot and intermediate temperature stars, of order of 10^{-14} for cool stars. This condition requires an adequate treatment of radiative transfer, which is only possible by employing a suitable algorithm like our own Implicit Integral Method (see Simonneau and Crivellari, 1993; Crivellari and Simonneau, 1994).

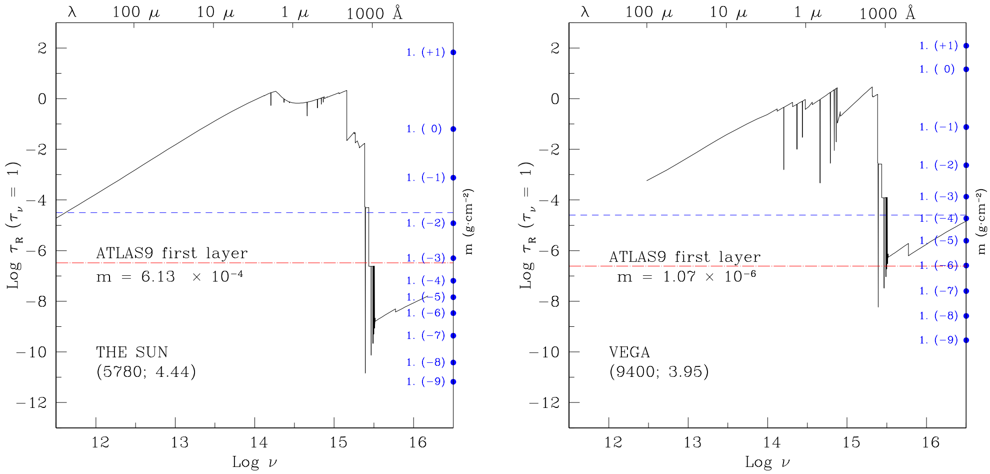

Figure 1. The Rosseland optical depth at which $\tau_\nu = 1$, namely the mean depth of formation, for each frequency of the spectrum. (For reference's sake the column mass depth is plotted on the left.) Two layers characteristic of the geometrical structure are indicated for the ATLAS9 models. By the dot and dash line the outermost layer, *viz* the geometrical surface. By the dashed line the effective surface of the model: the spectral regions formed above it cannot be computed correctly because not enough optical depth points are available for a proper treatment of radiative transfer.

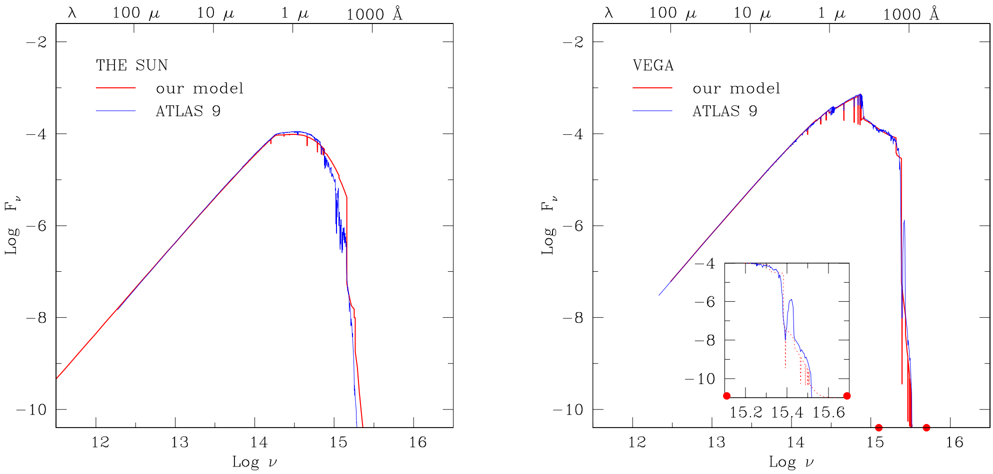

Figure 2. The emergent spectrum. For cool stars, like the Sun, a significant difference shows up in the UV. As clearly shown in Fig. 1, the corresponding portion of the spectrum forms in regions either not reached or poorly represented by Kurucz's models. For hotter stars, like Vega, the synthesized continua coincide. These continua form in regions below the effective surface of Kurucz's models. But the latter cannot account correctly for the formation of the strong lines, which are formed in regions above the effective surface. (Inside the zoom our spectrum is indicated by the dotted line.)

References

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