# The H$\alpha$ Balmer line as an effective temperature criterion

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Note: this poster is a summary of a more detailed paper Cayrel et al. 2011, A&A, **531**, A83

# Introduction

Already many authors have used the H$\alpha$ Balmer line as effective temperature criterion. Two events justify to derive a new calibration of H$\alpha$ versus effective temperature.

The first one is a continuous improvement in the physics of the broadening of the line, from 1999 to 2008. The second one is the enormous gain in the accuracy of apparent angular diameter measurements by interferometric methods.This enables to derive the effective temperatures of a dozen of stars with an accuracy of the order of one per cent by the relation

$$T_{\text{eff}} = (4/\sigma)^{1/4} fbol^{1/4} \theta^{-1/2}$$

where $\sigma$ is the Stefan-Boltzmann constant, and $fbol$ and $\theta$ are respectively the apparent bolometric flux and limb-darkened angular diameter of the object. This is the so-called direct method, less model dependent than the Infrared Flux Method, largely used before. Our work has been to connect the effective temperature obtained by the direct method, to the effective temperature of the model giving the best fit between the computed and the observed profile of H$\alpha$ for this dozen of stars.

## Effective temperatures from H$\alpha$

**Observations**: we selected the spectra of the S4N spectral library (Allende Prieto et al. 2004, A&A 420, 183) for the 10 stars having apparent angular diameter measurements better than 2 per cent. These spectra are very suited for the study of the H$\alpha$ wings, usually difficult to get with cross-dispersed spectrographs.

**Model atmosphere**: we used Kurucz ATLAS9, BALMER9 codes, after incorporating the Stark broadening of Stehlé & Hutcheon (1999) (A&AS, 140, 93) and the collisional broadening by neutral H of Allard et al. (2008) (A&A 480, 581). We used a mixing length over pressure scale height ratio of 0.5.

**Fitting procedure**:

As done by Barklem et al. (2002) (A&A 385, 951) we have selected windows, delimitated by vertical lines, where H$\alpha$ is not contaminated by other stellar lines (see Fig. 1 giving the red wing of the observed solar H$\alpha$). The telluric lines, indicated by red arrows, have been a worry as they move with the radial velocity of the object and must be avoided too. Some windows may be lost.

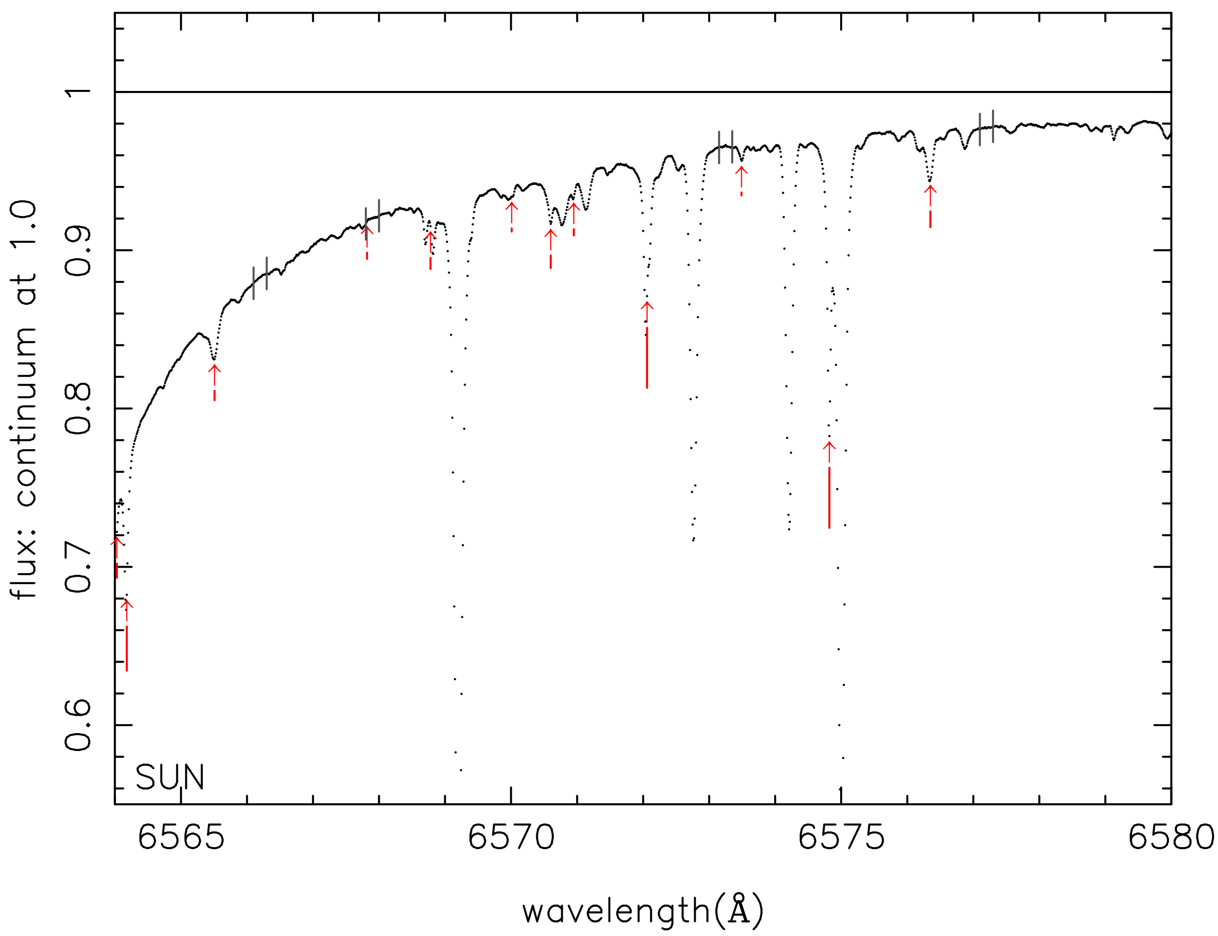
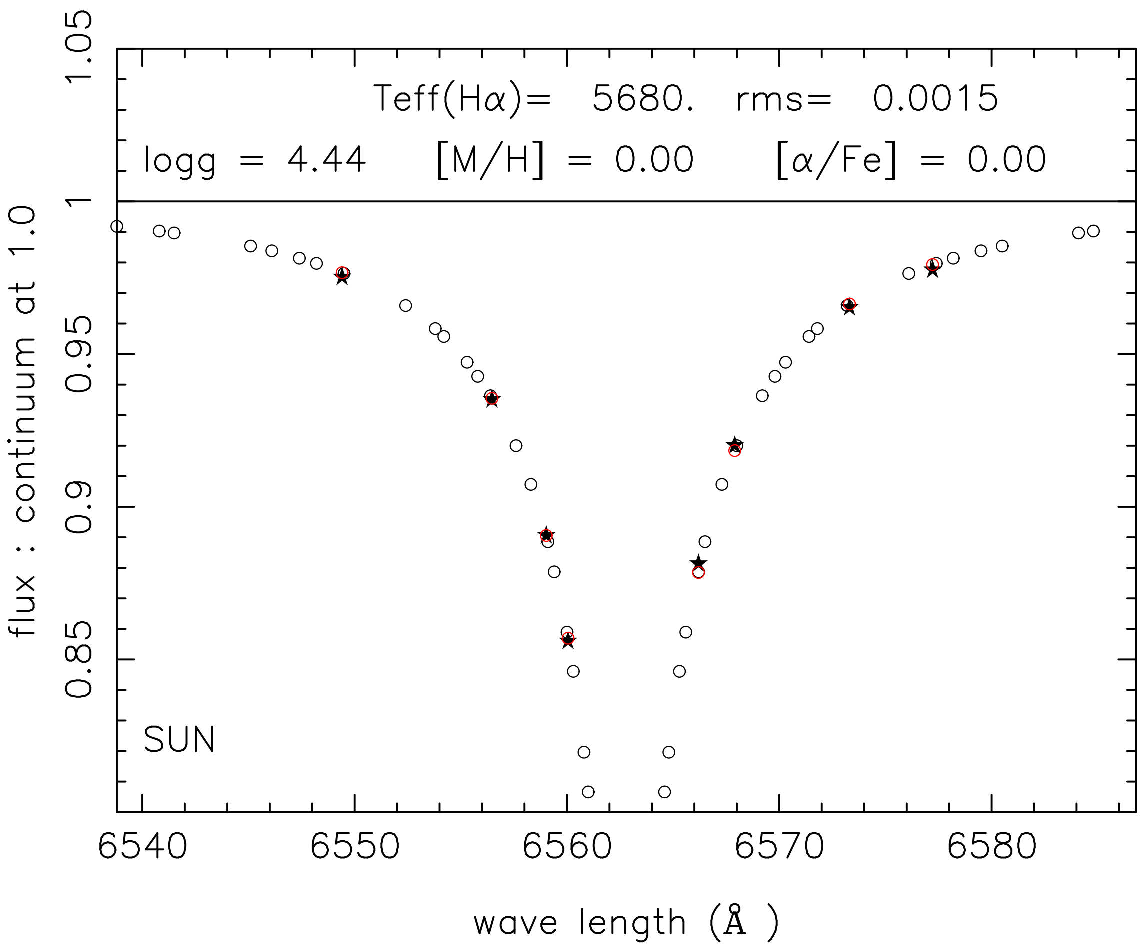



Figure 1

Taking the parameters gravity and metallicity from the PASTEL database (Soubiran et al. 2010, A&A 515, A111), we vary the effective temperature of the model until we get the best fit with the observed profile.




## Figure 2

Fitting of the computed to the observed fluxes of the solar H$\alpha$ profile. Open circles are the theoretical profile, the red ones corresponding to the wavelength of the observed points represented by full black stars.

See examples in Figs. 2 and 3. The procedure is repeated for the ten spectra from the S4N plus the Sun.

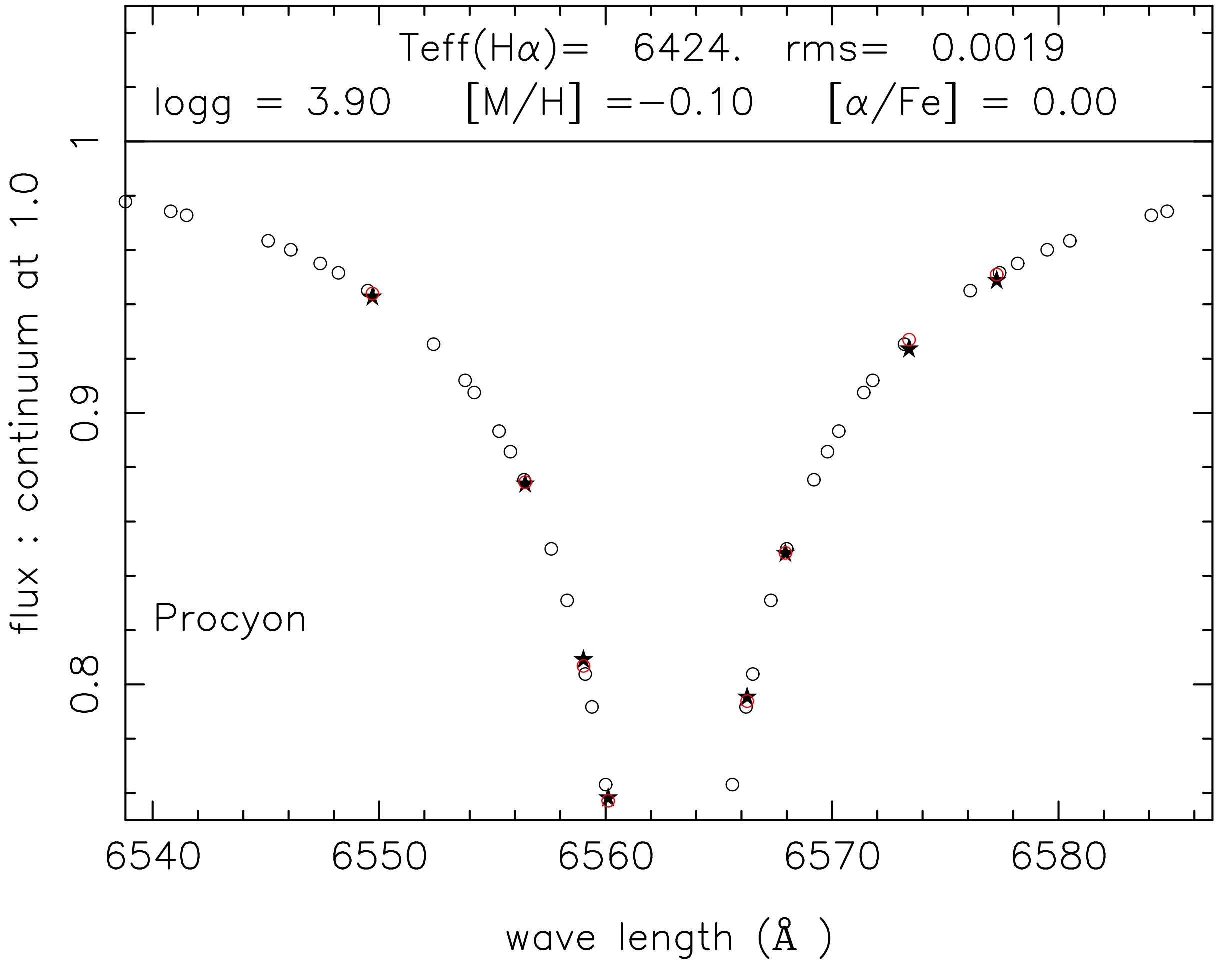



Figure 3

Fitting of the computed to the observed fluxes on the $H\alpha$ profile of Procyon.

# Teff(direct) and results

The apparent angular diameters have been taken from the litterature. Most of them come from the Mount Wilson interferometer (now CHARA) and a few from the ESO VLTI. A list of them can be found in Casagrande (2010) (A&A 512, 54). The apparent bolometric magnitudes have been derived from colour indices by relations established by Casagrande (2010).

The principal aim of our paper has been met, a simple procedure for deriving the true effective temperature from the observed H$\alpha$ Balmer line profiles, enabling to bypass the uncertainties in the amount of interstellar reddening, critical for temperatures derived from photometric indices. All the calibration stars are all at distances less than 15 parsecs, therefore not affected by reddening.

The remaining interesting problem is to understand why the two sets of temperatures have an offset instead of being equal.This is clearly a problem for 3D hydrodynamical models, that we are investigating now.

Figure 4 displays the relation between the two sets of effective temperatures. The dispersion of the points around the regression line of Teff(direct) versus Teff(H$\alpha$) is remarkably small, with a root mean square deviation of only 30 K. The correlation coefficient between the two sets is 0.9976, a very tight connection.

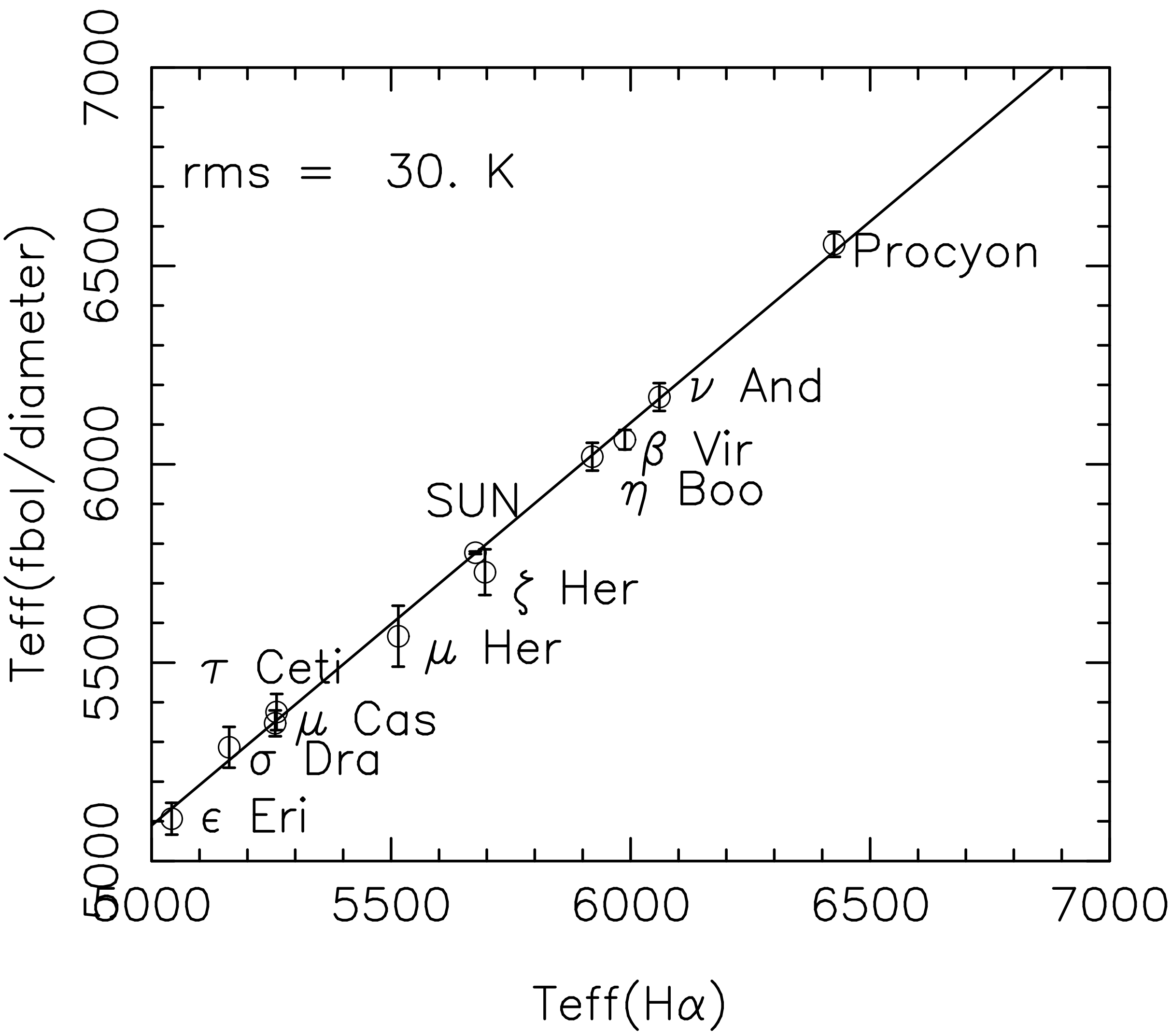



Figure 4

Regression line between $T_{\rm eff}$(H$\alpha$) and $T_{\rm eff}$(direct), represented by:
$T_{\rm eff}$(direct)= 20.3 + 1.014$\times T_{\rm eff}$(H$\alpha$).