Blaze residuals and their effect on the derivation of parameters of transiting planets

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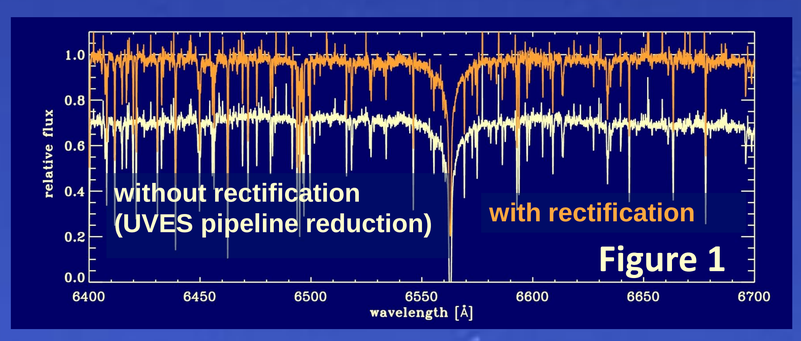
Abstract: The derivation of the properties of transiting planets depends critically on the adopted host star parameters. The determination of the latter often relies on the analysis of strong spectral lines. For example, effective temperature is usually derived from the wings of Balmer lines. The line profiles are extracted from Echelle spectra and thus can be affected by blaze residuals. The inspection of UVES spectra of OGLE-TR-10 shows that blaze residuals severely complicate the derivation of effective temperature although the residuals amount to a few percent only. They will be unnoticed in noisy spectra.

The example of the transit planet OGLE-TR-10b is presented to illustrate how uncertainties of effective temperature result in uncertainties of the derived planet parameters. Determinations of effective temperature of OGLE-TR-10 differ by hundreds of K. This is of the same order as the systematic uncertainties caused by blaze residuals in UVES spectra.

In order to correct for blaze residuals, it is essential to take spectra at sufficiently high signal-to-noise ratio. In addition, recipes of data reduction have to foresee intermediate steps to identify and remove blaze residuals.

Ammler-von Eiff & Santos (2008) compare the Hα profile of OGLE-TR-10 derived from UVES spectra in two different ways. They are obtained once with the UVES pipeline and once using intermediate data products of the pipeline plus additional steps. These include:

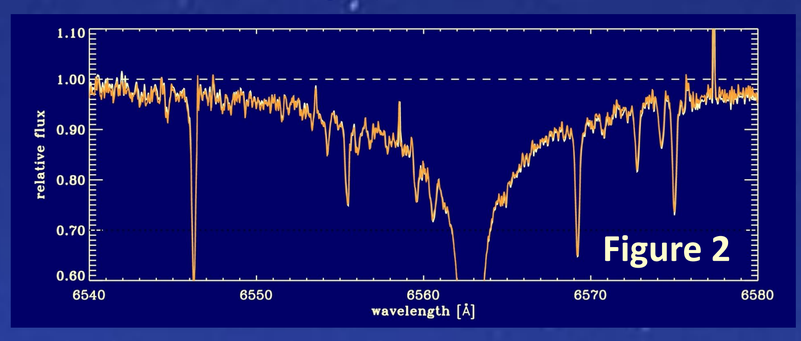
- Inspection of each Echelle order and identification of blaze residuals.
- Rectification including normalization and removal of blaze residuals.
- Checking the previous step by comparing overlapping parts of Echelle orders.
- Final adjustments and merging of Echelle orders.



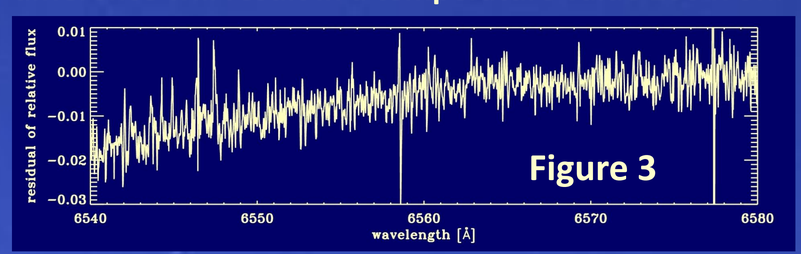
Effective temperature is then derived by fitting synthetic line profiles to the Hα line wings. The line core is not used. The synthetic profile shall match the curvature of the wings and further out the level of the continuum. The value of effective temperature will depend on

- the exact location of the continuum.
- the curvature of the line wings.

Without rectification, the continuum cannot be securely identified since there is curvature due to blaze residuals (see Fig. 1).



In the line wings, the difference between the profiles is hardly visible and would not be noticed in a noisy spectrum (Fig. 2). The residual plot (Fig. 3) shows that without rectification, the left Hα wing is off by 2%. The offset does not only affect the continuum level adopted but also the curvature of the wings. The tiny difference will result in a temperature value 200 K off.



In summary, only the rectified UVES spectrum can be used to securely derive effective temperature. Without rectification, the true continuum level cannot be assessed neither far away nor close to the line center. The curvature of the line wing will not be reliable. Finally, the left and the right wing will yield different values of effective temperature. Differences can be of the order of a few hundred K.

Different groups measured the radius of the planet OGLE-TR-10b and got discrepant results which not only depend on the photometric data used but also on the effective temperature adopted.

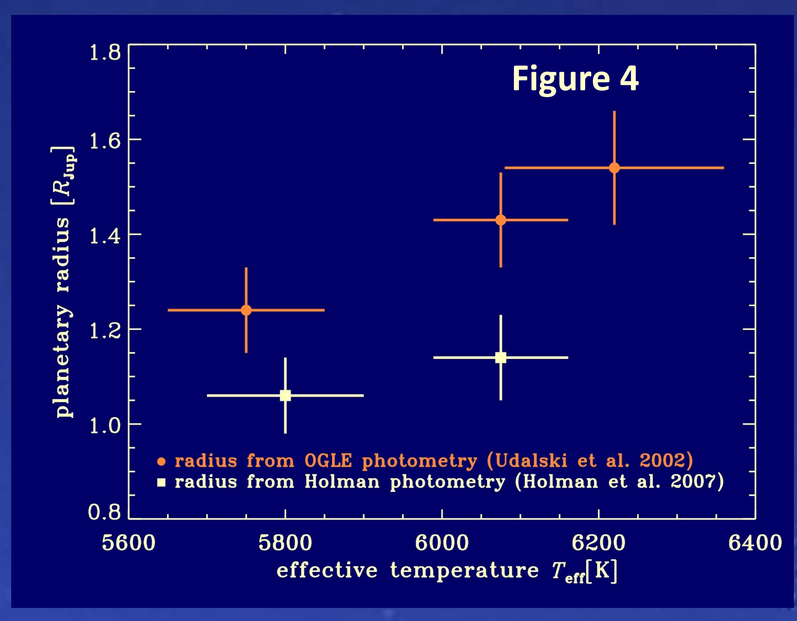


Figure 4 illustrates the effect of different temperatures adopted. Systematic uncertainties due to uncorrected blaze residuals will affect measurements of planetary radii in the same way. Values of effective temperature higher by a few hundred K correlate with an increase of derived planet radius by about 20%.

Lessons learned from OGLE-TR-10 include:

- Blaze residuals should be minimized by instrument design, e.g. FOCES (Pfeiffer et al., 1998; Korn, 2002) or UVES in fibre mode (Korn et al., 2006; 2007).
- Spectra need to be taken at sufficient signal-to-noise ratio to permit the identification and removal of blaze residuals.
- Data reduction needs to foresee intermediate steps to identify and remove blaze residuals.

Literature:

Ammler-von Eiff & Santos (2008, AN 329, 573)
Holman et al. (2007, ApJ, 655, 1103)
Korn et al. (2002, in "Scientific drivers for ESO future VLT/VLTI instrumentation", p. 199)
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