The recalibration of the UVES-POP stellar spectral library

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Abstract. We have re-reduced all spectra from the UVES-POP stellar spectral library using the version 5.5.7 of the UVES pipeline and an algorithm we designed, which allows us to remove ripples in regions where echelle orders are stitched. These ripples are caused by the offset of a flat field with respect to a science frame and under- or oversubtraction of scattered light. We have also developed an approach to merge 6 UVES spectral chunks divided by gaps in the spectral coverage by using synthetic stellar atmospheres to predict the flux difference between the segments. At the end, we improved the flux calibration quality to 2% or better for 85% of 430 spectra in the library.

1. Motivation

High quality models of stellar populations are in great demand now – they are used to interpret galaxy and star cluster spectra to determine the age, metallicity and chemical abundances. An essential ingredient of stellar population synthesis is a library of stellar spectra. This work is aimed at the recalibration of the UVES-POP library (Bagnulo et al. 2003) to improve flux calibration to the level of 2% or better required to model stellar populations. Such level of precision is a non-trivial task for multi-order echelle spectra.

2. Introduction: About UVES-POP and its imperfections

UVES-POP is a stellar spectral library that includes spectra of ~450 stars collected with UVES (Ultraviolet and Visible Echelle Spectrograph) (Dekker et al. 2000) at ESO VLT in 2001-2003. Some important characteristics of UVES-POP stellar spectra:

- typical spectral resolution: \( R = \lambda/\Delta \lambda = 80000; \)
- the majority of spectra have SNR=300-500 per resolution element in the V band;
- wide coverage in the \( T_{\text{eff}}, [\text{Fe/H}], \log(g) \) parameter space.
2.1. The problem of ripples

Most of the original UVES-POP spectra have noticeable ripples in the regions where echelle orders are stitched. They are caused by (i) the offsets between science and flat field exposures and (ii) under- or oversubtraction of scattered light. Shift of flat-fields may have different reasons, but the most probable are temperature change in the dome of the telescope (flat-fields are taken in the evening or morning, but science frames at night) and mechanical flexures at different parallactic angles.

2.2. Inaccurate merging of spectral chunks

Merged UVES spectra have two gaps in the wavelength coverage due to the gaps between UVES CCDs. The flux difference on the two sides of each gap because of the spectral shape was neglected in the original UVES-POP reduction, and the flux level was equated: this caused ”steps” in flux.

2.3. Quality control

The quality control for the original UVES-POP spectra, which were reduced using an old UVES pipeline sometimes accepted poor quality spectra but rejected spectra of reasonable quality.
3. UVES-POP recalibration approach

We have re-reduced original UVES-POP data downloaded from the ESO Data Archive using the version 5.5.7 of the UVES pipeline. We also introduced algorithms to remove ripples and correctly merge spectral chunks. In order to eliminate ripples, we (i) shift the flat-field image with respect to the science frame and (ii) add or subtract a value proportional to the flux in order to account for imperfect scattered light correction: these two operations are run in a loop that minimizes the flux difference between overlapping order fragments.

We have also developed an approach to merge non-overlapping segments using synthetic spectra (PHOENIX (Husser et al. 2013) and BT-Settl (Allard 2014)) and stellar atmospheric parameters reported in the literature for UVES-POP stars: this allows us to estimate the flux difference between the both sides of each gap.

4. Additional steps

When we merge spectral segments, we also calculate the value of extinction E(B-V) on the line-of-sight. It allows us to deredden UVES-POP spectra for the future use in stellar population synthesis.

In the red part of the wavelength range (>680 nm) it is also important to correct the telluric absorptions originating from the Earth atmosphere. This will be done for the 1st data release.

Figure 2. Spectrum of the star HD320764 before (red) and after (black) correction for the interstellar reddening.

5. Web-based visualisation

We have developed a dedicated interactive web-service to view recalibrated UVES-POP spectra. Top left panel displays a 3D-plot of stars in the \( T_{\text{eff}}-[\text{Fe/H}]-\log(g) \) parameter space and allows one to choose any star in order to view and download its spectrum.
The preliminary version of the service is available at the following web-address: http://sl.voxastro.org/3d-viewer

Figure 3. An interactive web-based spectral viewer developed for the visualisation of spectra from UVES-POP and other stellar spectral libraries.

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