Southern African Large Telescope

Title: **Correction for the tilt of HRS spectra using MIDAS pipeline**

Author(s): **Alexei Kniazev**

Doc. number: **HRS0000009**

Version: **1.0**

Date: *March 26, 2018*

Keywords: HRS, Pipeline

Approved: **Encarni Romero Colmenero (AstOps Manager)**

ABSTRACT

In this report I present very simple way of correction for the tilted nature of lines in HRS spectra. The current version of the HRS MIDAS pipeline could be relatively easy updated with such tilt effect correction procedure. Its implementation makes FWHM and resolution $R = \lambda/\delta\lambda$ much more close to the declared values and does not destroy the wavelength accuracy.

South African Astronomical Observatory, Cape Town 7925, South Africa

Contents

List of Figures

1 Introduction

HRS is very useful instrument for those science cases, where we need the whole spectral region simultaneously with high resolution. The region of scientific usability of such instrument is very high. Unfortunately, I have found that not taking into account the tilted nature of lines with the current version of the HRS MIDAS pipeline (Kniazev, Gvaramadze & Berdnikov, 2016) results to the lost of the final resolution to about 50% for the HR mode, for example.

I did study this problem and found very simple solution, which could be implemented in case of the HRS MIDAS pipeline.

2 Method

As I described in details previously (Kniazev, 2016a), `FEROS` package splits order extraction into two separate steps. During the first step all information from the curved orders is extracting in an easy to handle format. Hereafter I will call these images "straightened" images. You can see examples of these images in the Kniazev (2016a). For echelle spectra with two fibers straightened data are stored in separate files for each fiber. As the result of this step user has images, where all orders found with procedure are extracted without rebinning and written into separate images. That gives a nice possibility to play with parameters of extraction like length of the extraction slit and shifts for each fiber from the defined center. This way of echelle data reduction also gives a nice possibility to correct straightened image for the tilted nature of lines and to continue with the final extraction of straightened echelle spectrum using the standard or optimum extraction algorithms.

For example, Figure 1 shows similar part of the straightened echelle spectrum of the first fiber of ThAr lamp before the correction for the tilt (top panel) and after (bottom panel). The tilt effect correction procedure was created by me during about an hour. The general idea of this procedure is very simple: the central row for each straightened order does not move, but all other rows for the same order shift proportionally to the tilt angle α, which has to be estimated somehow. As the first implementation for such algorithm, the tilt angle α was selected to be a constant for all extracted orders and was calculated on the base of one line in the middle of straightened image. For example, Figure 2 shows similar part of the straightened echelle spectrum of the first fiber of the velocity standard star HD 32820 before the correction for the tilt (top panel) and after (bottom panel).

3 Results

3.1 $R = \lambda/\delta\lambda$ after the correction for the tilt

I have repeated my work described in the previous report (Kniazev, 2018), where I calculated distributions of FWHM and R for different HRS modes. In the current report I repeat it only for the HR mode since this mode showed the largest difference between calculated and

Table 1: Comparison of declared and calculated R for HRS

Mode & Arm	Declared	Calculated before tilt	Calculated after tilt
	R	R	R
(1)	(2)	(3)	(4)
HR Blue	65000	44000–46000	50000–58000
HR Red	74000	47500–45500	64000–70000

declared R = $\lambda/\delta\lambda$ values. All new calculations were done for data, which were corrected for the tilt during their reduction with newly created simple procedure.

All old and newly calculated distributions of FWHM and R for HR mode are plotted in Figures 3 and 4. Table 1 shows my results in very short form, where R values declared in our **"Call for Proposals" document** are compared to the old and newly calculated R values. The old calculated R for the HR mode was less of about 44% for the Blue channel data compare to the declared and less of about 59% for the Red channel data. After simple correction for the tilt the calculated average R value started to be much close to the declared with about 20% less for the Blue channel and 10% less for the Red channel in average. The newly calculated R distributions (blue and red colors for the Blue and the Red channels correspondently), which are shown in Figure 4 have much more curved shape compare to the old distributions (cyan and magenta colors). These shapes reflects the fact that the tilt angle has changing value depending on the order number. In our case, since it was selected as the constant for the middle of covered spectral region, the best resolution appears to be for the middle of the spectral region for the each channel. This best resolution R is much more close to the declared values.

3.2 Wavelength calibration accuracy after correction for the tilt

Another important item for this study was to prove that wavelength calibration of HRS data is correct after such simple procedure correction for the tilt. For that reason I have used RV standard HD 32820, which was observed with HR mode next night after ThAr calibrations were taken, which I have used in my study. The result of this comparison is shown in Table 2. Column (3) presents calculated heliocentric velocities for the spectrum of HD 32820, where it was reduced in the "regular" way with the HRS MIDAS pipeline. Column (4) presents calculated heliocentric velocities for the same spectrum, where both ThAr and spectrum of HD 32820 where corrected for the tilt. In the second case the final velocities for both channels look correct and coincide with declared values taking into account the total errors.

Table 2: Comparison of calculated radial velocities

Mode & Arm	Declared Velocity	Calculated without tilt	Calculated with tilt
(1)	(2)	(3)	(4)
HR Blue	29.823±0.867	29.911±0.269	30.497±0.238
HR Red	29.823±0.867	32.019±0.327	30.270±0.470

4 Conclusions

I have presented the simple procedure to correct for the tilt nature of lines in HRS spectra and its implementation for the HR mode. I have study FWHM and $R = \lambda/\delta\lambda$ distributions for HR mode of HRS after correction for the tilt effect.

The main conclusion of this report is that the current version of the HRS MIDAS pipeline could be relatively easily updated with the tilt effect correction procedure. Its implementation will improve resolution and will not destroy the wavelength accuracy.

References

Kniazev A. Y., 2016, "HRS pipeline for LR red-arm data with MIDAS", SALT Report, p.1
Kniazev A. Y., 2018, "FWHM and $\lambda/\delta\lambda$ for HRS with MIDAS pipeline", SALT Report, p.1
Kniazev A. Y., Gvaramadze V. V., Berdnikov L. N., 2016, MNRAS, 459, 3068

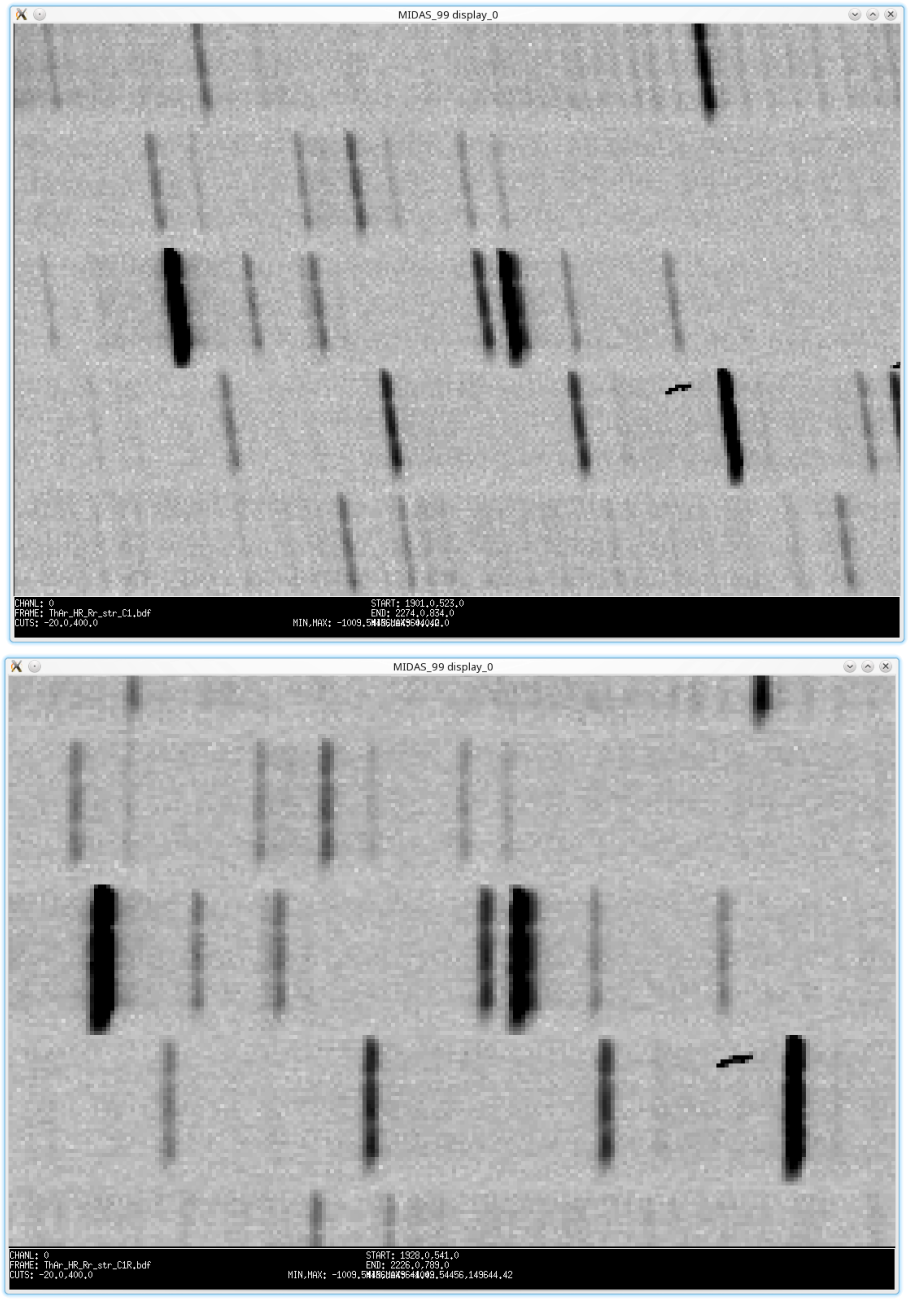

Figure 1: The part of the straightened echelle spectrum of the first fiber of ThAr lamp before the correction for the tilt (top panel) and after such correction (bottom panel).

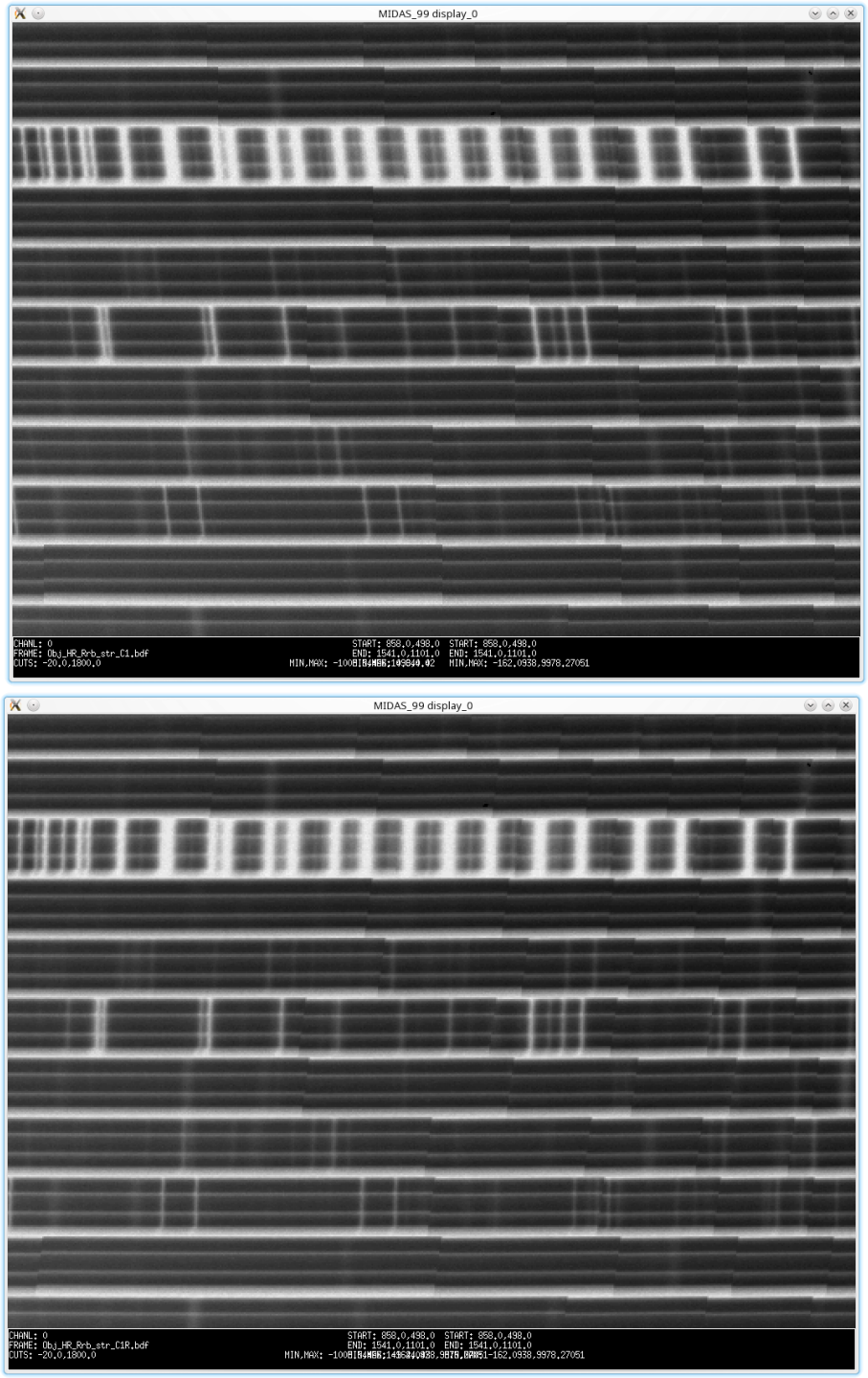

Figure 2: The part of the straightened echelle spectrum of the first fiber of the velocity standard star before correction for the tilt (top panel) and after such correction (bottom panel).

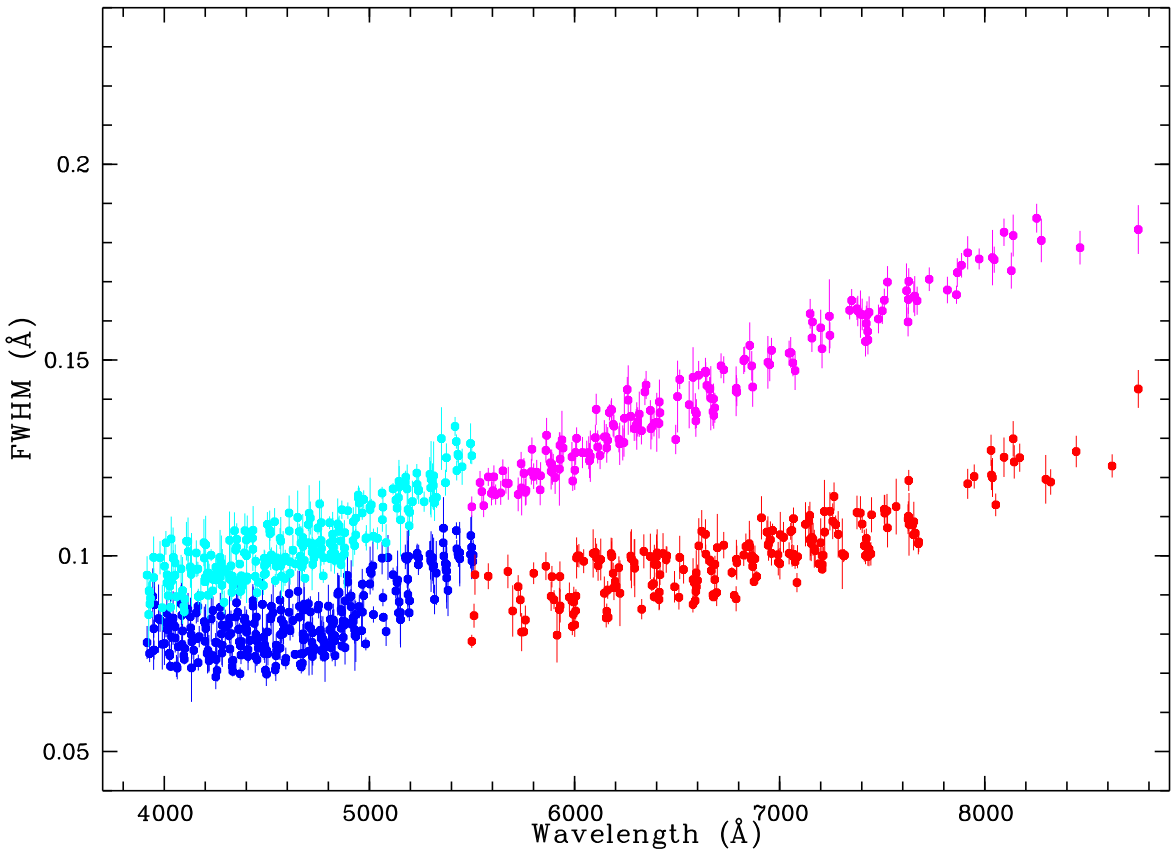

Figure 3: The distribution of FWHM for HR mode. Measurements for the Blue channel are shown with cyan color before correction for the tilt and with blue color after such correction. Measurements for the Red channel are shown with magenta color before correction for the tilt and with red color after such correction. $\pm 1\sigma$ errors for each line are shown.

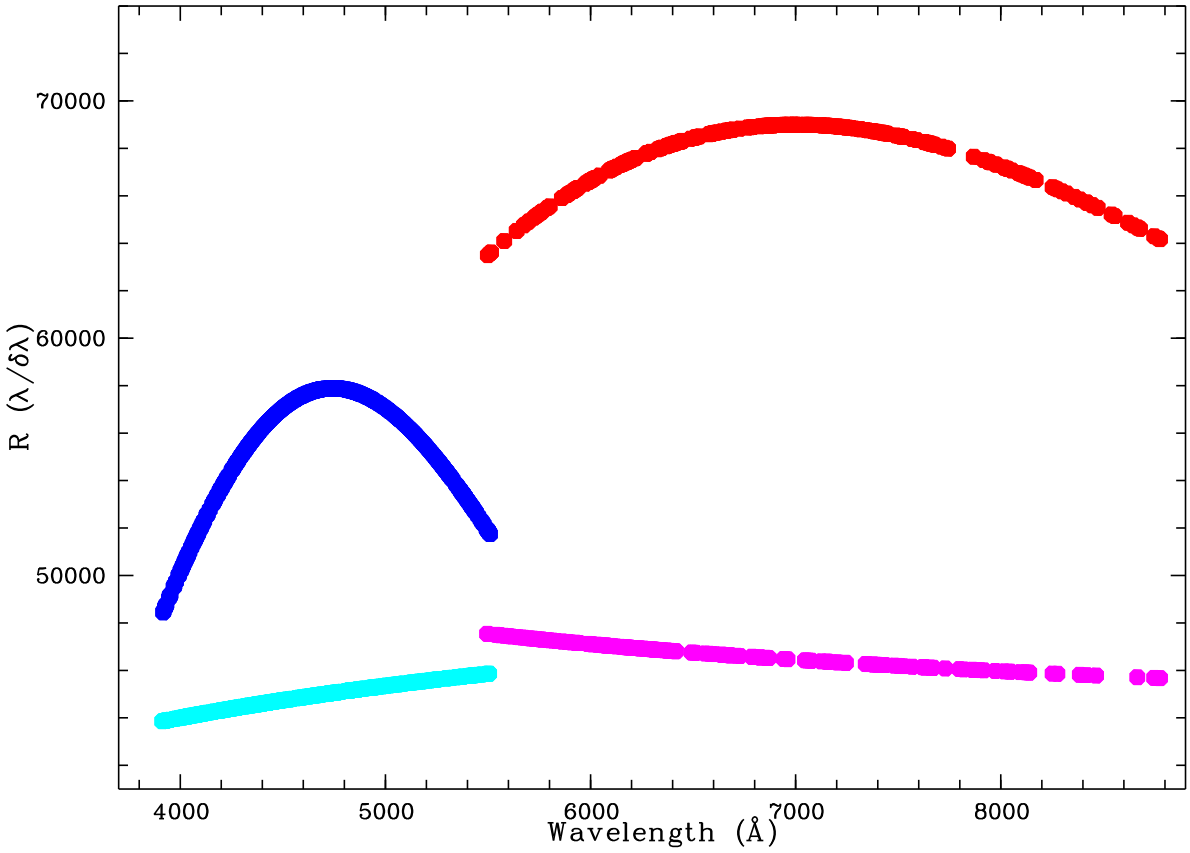

Figure 4: The distribution of R = $\lambda/\delta\lambda$ for HR mode. Measurements for the Blue channel are shown with cyan color before correction for the tilt and with blue color after such correction. Measurements for the Red channel are shown with magenta color before correction for the tilt and with red color after such correction.