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Science Operations
Technical report on EMMI red gratings # 8 and 13

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1 Introduction

The efficiency of the system EMMI red + telescope was re-measured for all the observing modes following the upgrade of the red CCD. As a consequence of the upgrade, with a more efficient detector, a new exposure time calculator (hereafter ETC) was needed, so all the measured curves were sent to the DMD in Garching: at the end of 2003 a newer version of the ETC for EMMI was released to ls-sciops only. Cross-check between the ETC estimates and the measured S/N resulted in satisfactory agreement (within 20%) for RILD (imaging and spectroscopy), BIMG, BLMD, REMD-echelle and for gratings #6 and #7 of REMD. A strong disagreement was found instead between the ETC estimate and the S/N measured on standard star spectra taken with gratings #8 and #13. It was then decided to offer the new ETC to the astronomical community, but to take out gratings #8 and #13 until a complete investigation could be carried out. At the same time a warning was placed on the main EMMI webpage.
A discussion of the problem with former instrument scientist S. Brillant ended with the communication that gratings #8 and #13 suffered from severe second order contamination and non-linear behaviour away from blaze angle. It was then decided to observe a full set of spectrophotometric standards with blue and red color under stable weather conditions to deal with all problems at once, with observations to be done at the first good technical night, i.e. clear sky.

1.1 Applicable documents

The following documents, of the exact issue shown, form a part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document shall be considered as a superseding requirement:

1.2 Reference documents

The following documents are referenced in this document:

[3] LSO-MAN-ESO-40100-0001/5.0 EMMI Users' Manual

1.3 Abbreviations and acronyms

The following abbreviations and acronyms are used in this document:

SciOp	Science Operations
LSO	La Silla Observatory
ESO	European Southern Observatory
EMMI	Eso Multi Mode Instruments
RILD	Red Imaging and Low Dispersion
BLMD	BLue Medium Dispersion
REMD	REd Medium Dispersion

1.4 Glossary

1.5 Stylistic conventions

The following styles are used:

bold	in the text, for commands, filenames, etc., as they have to be typed.
italic	for parts that have to be substituted with real content.
`teletype`	for examples.

Bold and *italic* are also used to highlight words.

2 Overview

To quantify at the same time the S/N obtainable with gratings #8 and #13 and the amount of second order contamination, we need to observe very red and very blue standards with an high S/N. If a second order contamination is present, we expect to observe a rise in the efficiency curve of the blue standars beyond 680 nm (2x atmospheric cutoff at 340 nm), while the efficiency curve derived from redder stars should either flatten out (smaller second order contamination) or decrease with distance from blaze. An high S/N allows a good determination of system efficiency with small errors.
Another way of quantifying the amount of second order contamination is to search for blue lines in the red part of an arc frames: however this method is more difficult, since it relies on the identification of faint (blue) lines superimposed on very bright ones (red), hence we preferred the first solution.

2.1 Set-up, observations and data reduction

During the test we planned to cover the full wavelength range of EMMI red, from 400 nm to 1050 nm, hence the gratings were set-up for central wavelengths of 520 nm (blaze), 620 nm, 720 nm and 820 nm for grating #8 and of 550 nm, 650 nm (blaze), 750 and 850 nm for grating #13.
Observations were carried on during technical nights of May 26 and 27, 2004. Sky conditions were clear and reasonably stable during the night of 26, while the weather degraded on the 27, so only data from the night of 26 to 27 May were used. Five spectrophotometric standards were observed at each wavelength in both gratings through a 5" slit; their properties are listed in Table 1.

Table 1: Spectrophotometric standars chosen for the test

Name	V mag	(B-V)
cd 32-99d7	10.44	+0.34
EG274	11.73	-0.14
LTT4816	13.79	+0.17
LTT6248	11.80	+0.49
LTT7379	10.23	+0.61

Relevant calibrations (biases, dome flats and arcs) were taken in the afternoon.
Data reduction was done with an upgraded version of the EMMI quicklook tool for long-slit spectroscopy, *quickred* (module nttplemmi, v.2.5), using master calibration frames built from the afternoon frames through ancillary scripts and the MIDAS context long: the final data product is a one dimensional, bias subtracted, flat-field corrected and wavelength calibrated spectrum summed up along 3 x FWHM pixels, slightly larger than the one used in the ETC but it ensures that also the wings of the stellar profile are included.
The dispersion solution was calculated on the two-dimensional arc frames, accounting in this way also for geometrical distortion on the frames. A good solution was obtained with a third degree polynomial fit along the dispersion direction and a second order polynomial fit along the spatial direction. Both gratings #8 and #13 can be said to have a very smooth dispersion solution for the full wavelength range of EMMI red, without any strange behaviour or non-linear dispersion.
A side product of this test was a full set of new calibration frames for gratings #8 and #13, i.e two dimensional dispersion solutions for all the central wavelengths and master flats, which have been transferred to the off-line workstation to be used within the *quickred* tool.

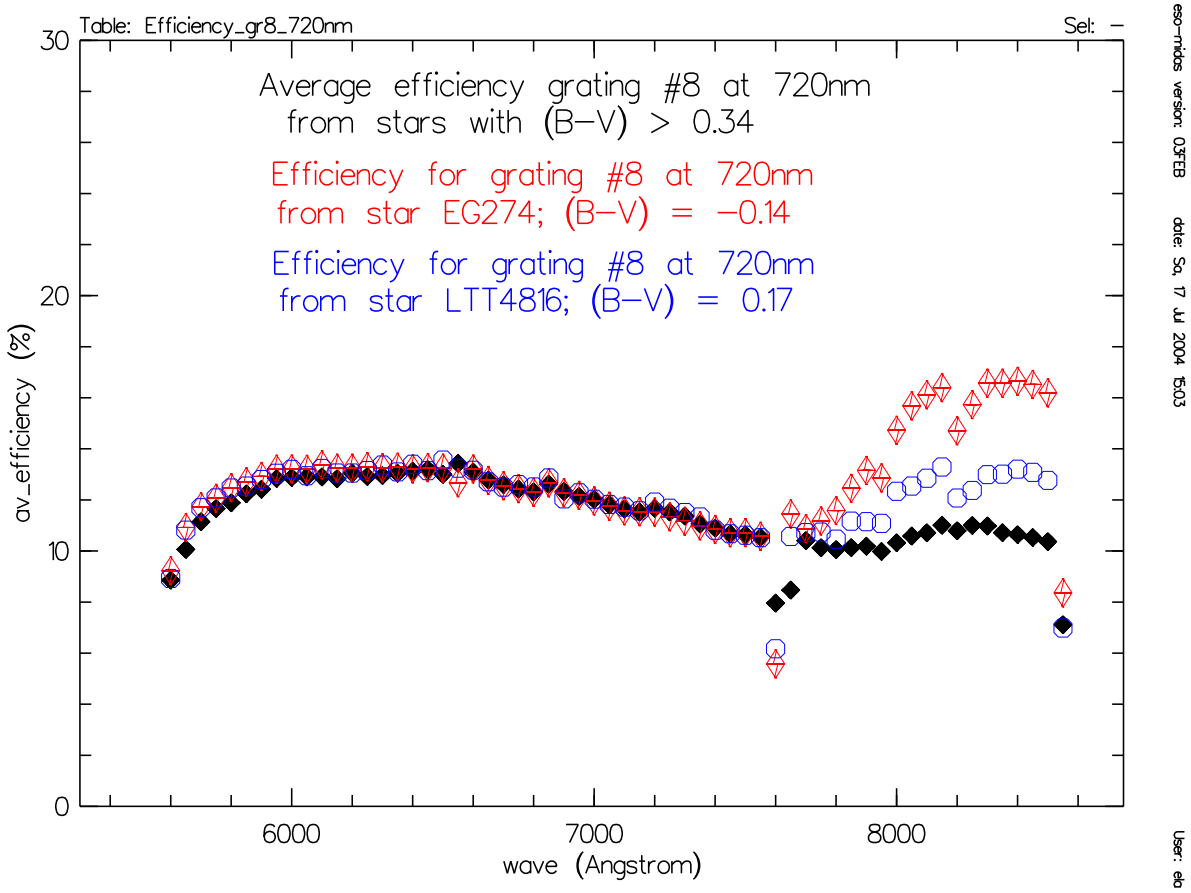

Figure 1: Average system efficiency for grating #8 at central wavelength 720 nm. A strong second order contamination is clearly visible for bluer stars.

3 Analysis

To evaluate the amount of second order contamination we determined the system efficiency (EMMI+telescope) for each spectrophotometric standars separately, using the script *efficiency.prg* available on the EMMI calibration plan web page and archived under the cmm module nttplemmi, v.2.5. Basically the script compares the observed one-dimensional, wavelength calibrated and extinction corrected standard star spectrum with the tabulated spectrum from Hamuy et al. (PASP, 104,533, 1992; PASP, 106, 566, 1994.) This mean to obtain five separate curve at each central wavelength for the two gratings, one curve for each of the five spectrophotometric standards.
Following this, we defined an average system efficiency by averaging together those curves which did not differ from each other more than 2% along the wavelength range covered by a particular set-up. This constraint immediately excluded the two bluest stars of our sample, namely LTT4816 and EG274, due a strong deviation from the average caused by the second order contamination, which is very visible for blue object.
The average system efficiency was compared with that derived from these two stars and the amount of second order contamination was defined as the percentual increase in system efficiency calculated from star EG274, as the bluest object of the sample, with respect to the average efficiency at the same wavelength. An example of second order contamination for grating #8 is shown in Figure 1.

The main results of this exercise can be summarized as follows:

- the average efficiency curves nicely overlap on each other, confirming a smooth grating behaviour; the

Table 2: Second order contamination for gratings #8 and #13 of EMMI red measured with respect to EG274 vs stars with average (B-V) color 0.34.
λ_{peak} is the wavelength at which the second order contamination is maximum for the chosen standard, EG274

Grating	λ_c (nm)	Contamination?	Amount of contamination at peak	λ_{peak} (nm)
8	520	no	-	-
8	620	no	-	-
8	720	yes	64%	834
8	820	yes	65%	900
13	550	yes	25%	815
13	650	yes	30%	815
13	750	yes	30%	845
13	850	yes	37%	943

EMMI web pages have been updated with the new measured efficiencies.

- Second order contamination starts at $\sim$ 760nm for gratings #8 and #13;
- the amount of second order contamination varies from 25% to 65%; the full information is given in Table 2. It must be noted that the quoted limits must be intended as lower limits when one is observing blue targets, with a (B-V) color comparable to that of EG274, -0.34, since we did not re-observe the stars with an order sorting filter.

4 Conclusions

From the data analysis shown before we can conclude that:

- Gratings #8 and #13 must **always** be used with an order sorting filter beyond 760nm;
- the dispersion solution of the gratings is well behaved over the full wavelength range of EMMI red
- the average system efficiency curves derived from red stars at different grating angles join smoothly in the overlap regions.
- To get an absolute characterization of the amount of second order contamination optical bench measurements of the gratings would be needed.
- The new efficiency data have been sent to Garching, so that new ETC checks can be performed; it was not possible to do it at the time of writing, because the ETC for gratings #8 and #13 is not on-line even on the Garching development machine. A local version of the ETC would be an advantage.
- The ETC has been updated with the new efficiency curves derived from the new data: the agreement between the measured S/N on the spectra and that predicted by the ETC is good to better than 10% level in most of the cases and it does never become worst than 20%, in agreement with the ETC requirements. The full EMMI ETC is now on-line.

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