NON LINEARITIES IN IUE DATA

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Abstract

IUE detectors present a highly non-linear response with large spatial variations along the camera faceplate. A correct interpretation of the data requires an accurate correction for this lack of linearity. This work presents an evaluation of the residual non-linearities existent in the extracted spectra after the corresponding corrections have been applied, and discusses the possible influence of different extraction algorithms.

Key words: IUE; Data Analysis.

1 INTRODUCTION

One of the most critical steps in the reduction of IUE data is the Photometric Correction, which takes into account the intrinsic lack of linearity of the detectors.

This correction is performed through the so-called Intensity Transfer Functions (ITFs), which are derived from series of graded lamp exposures. These functions are used to transform the raw Data Numbers (DN) of each pixel in the Raw Image into linearized Flux Numbers (FN) in the Photometrically Corrected Image and the SILO, under the assumption that over small differential flux ranges, the relation can be approximated by a linear interpolation. NewSips uses newly derived ITFs for the three Cameras, obtained under well controlled Spacecraft conditions, and determined through improved algorithms.

Since neighboring pixels may have very different linearity characteristics, the accuracy of the geometrical correction is crucial to guarantee that each pixel is corrected with its own function. The new approach applied to perform the geometric correction in NewSips (cross correlation of the Raw Image against the ITF, originally developed by Dravins et al. (1993)) ensures a better photometric correction than in previous processing systems. A full description of the construction of the ITFs and of the NewSips geometric correction algorithm can be found in Garhart et al. (1997, Chapter 7).

Final extracted spectra show however some residual non-linearities that are not completely corrected during the processing. The most likely cause is the breakdown of the linearity assumption between adjacent levels at the extremes of the ITF.

This paper presents an evaluation of such an effect, and discusses the possible influence of the extraction algorithms (i.e. INES *vs.* SWET).

Table 1: *Spectra used in the study*

SWP			LWP			LWR		
Texp sec	DN gross/bck	Level	Texp sec	DN gross/bck	Level	Texp sec	DN gross/bck	Level
2.33	31/15	9 %	9.71	70/30	19 %	19.54	82/28	33 %
5.20	39/15	20 %	19.54	99/30	39 %	33.87	115/29	57 %
7.65	54/14	29 %	29.78	133/29	60 %	*59.68*	*186/28*	*100 %*
10.52	76/14	40 %	39.61	166/30	79 %	99.82	255/31	167 %
15.84	107/15	60 %	*49.85*	*176/28*	*100 %*	149.79	255/32	251 %
21.17	137/16	80 %	49.85	181/29	100 %			
26.49	*162/16*	*100 %*	64.59	210/30	130 %			
32.23	192/16	122 %	74.83	231/30	150 %			
40.01	222/16	151 %	99.82	255/30	200 %			

2 THE SAMPLE OF DATA

This study has been performed with a sample of low resolution large aperture spectra of the standard star BD+28 4211. For each camera, spectra with different exposure levels were taken consecutively under similar temperature conditions. One of the spectra is defined as a 100 per cent exposure, and the rest are referred to that one.

- SWP: Nine spectra taken in December 1993, with exposure times ranging from 2 sec (9%) to 40 sec (150%). The 100 % spectrum has an exposure level of 162 DN (including a background of 16 DN).
- LWP: Nine spectra taken in October 1986, with exposure times ranging from 10 sec (20%) to 100 sec (200%). The reference spectrum has an exposure level of 176 DN (including a background of 28 DN).
- LWR: Five spectra taken in August 1980, with exposure times ranging from 20 sec (30%) to 150 sec (250%). The 100% spectrum has an exposure level of 186 DN (including a background of 28 DN). All this spectra have been processed with ITF–B, which is the one giving the best correlation coefficient in this case, as in most of the pre-1984 LWR spectra.

Full details of the spectra used are given in Table 1. Levels in italics are those used as reference for each camera. Listed in the table are also the maximum Data Number (DN) of the spectrum on the Raw Image, and the average DN in the background close to the spectrum. The listed exposure times are effective (i.e. corrected for OBC tick rounding and Camera Rise Time). All the spectra have been extracted both with SWET (the

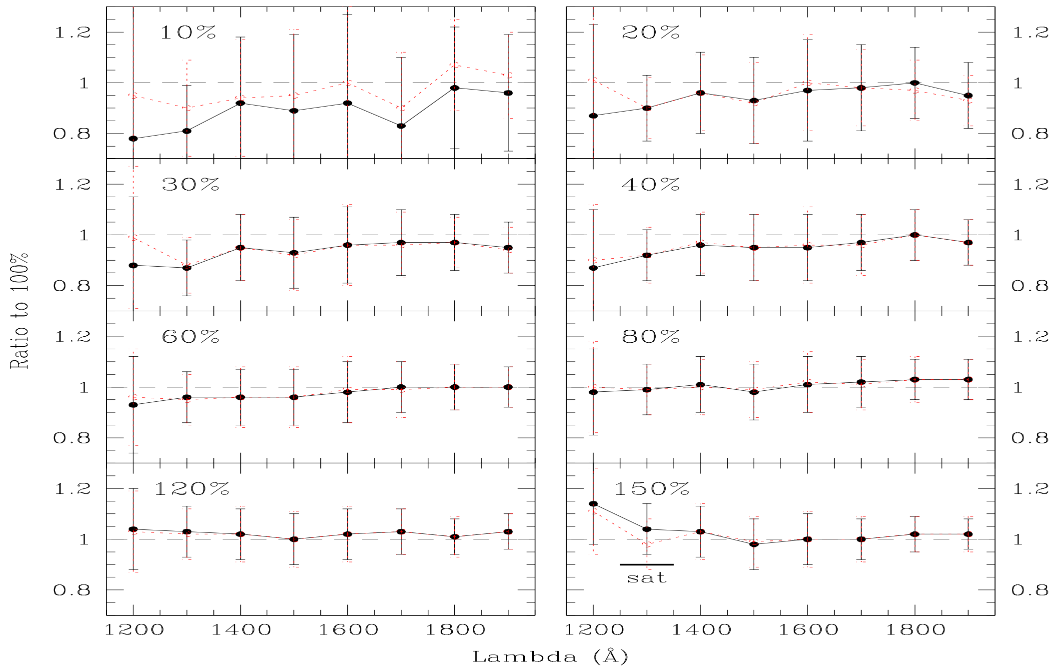

Figure 1: *Ratios of spectra with different levels of exposure to the 100% spectrum for the SWP camera. The continuous line corresponds to the INES extraction, and the dotted one to SWET. Horizontal lines mark saturated regions of the spectra*

standard NewSips extraction algorithm), and with INES (see Rodríguez-Pascual et al., this volume).

The procedure followed was to bin every spectrum in 100 Å bands and divide it by the corresponding reference exposure. Errors in the ratios have been computed from the sigma values derived in the extraction procedure.

3 RESULTS

Figures 1 to 3 show, for each of the three cameras, the ratios of the individual spectra to the reference spectrum, both for the SWET and for the INES extractions.

3.1 Comparison of INES and SWET extractions

In the case of the SWP Camera, differences between both extractions are small, except for the most underexposed spectrum, for which SWET results are better. The most likely reason for this difference is that the fitting of the background, highly critical for this type of underexposed spectra, is not satisfactory in the INES extraction. In the saturated region of the 150% spectrum the flux given by SWET is also better.

The largest differences between SWET and INES in the LWP Camera are found at the edges of the spectra, specially in the most underexposed ones. In these regions INES

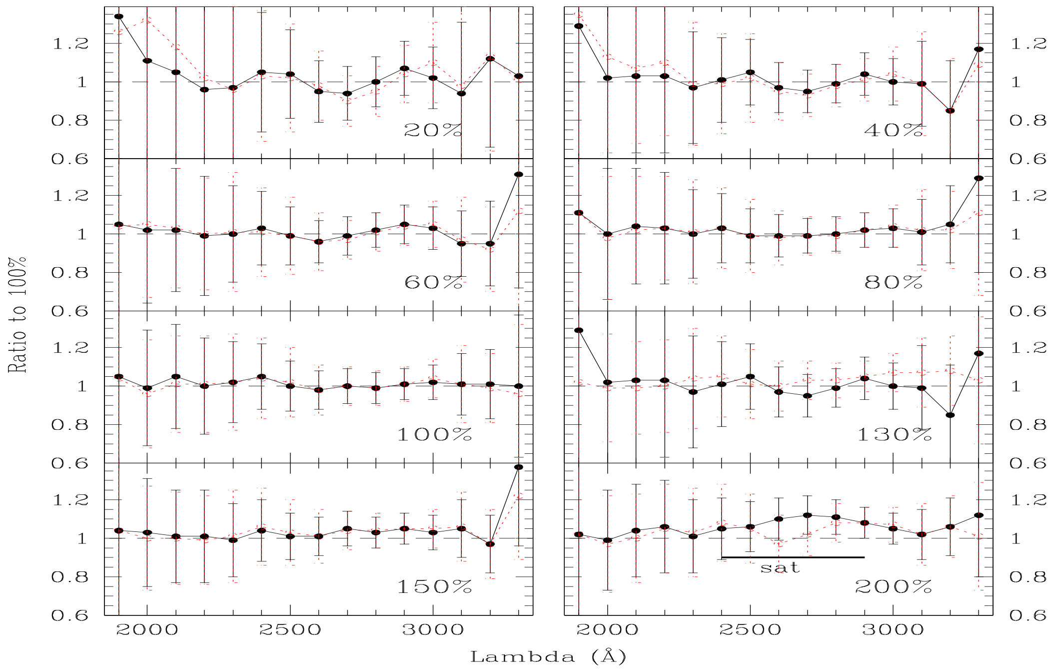

Figure 2: *Same as Figure 1, for the LWP camera.*

results are better for the 20% and 40% spectra. SWET gives better results in the saturated regions.

For the LWR(ITF-B) Camera, INES gives results similar or better than SWET in all cases. Contrary to what happens in the other two cameras, INES results are also better in the saturated spectra, where SWET underestimates the flux by a 30% or more.

3.2 Linearity of INES data

Examples of the behaviour of different spectral bands for each of the cameras as a function of the level of exposure are shown in Figure 4.

In the SWP Camera, the lack of linearity becomes more important at the short wavelength end of the underexposed spectra, where flux can be underestimated by up to a 20%. Apart from this case, longward Lyman α, ratios to the 100% spectrum are within $\pm$ 5%, except in the 1300 and 1500 Å bands of the less exposed spectra. The best results are achieved in the 1800 Å band, where linearity is within $\pm$3%.

For the LWP Camera the largest non-linearities occur at the extreme bins of the spectra (1900, 3200 Å), where the flux can be largely overestimated. Except for these bands, linearity remains within $\pm$ 5% for spectra with exposure levels from 40% to 150%. The flux in the saturated part of the most exposed spectrum is overestimated by 10%. Excluding the saturated points, the bands which show the best linearity characteristics (within $\pm$ 3%) are those centered at 2800 and 3000 Å.

The LWR Camera shows the largest non-linearities at the longest wavelengths of the most

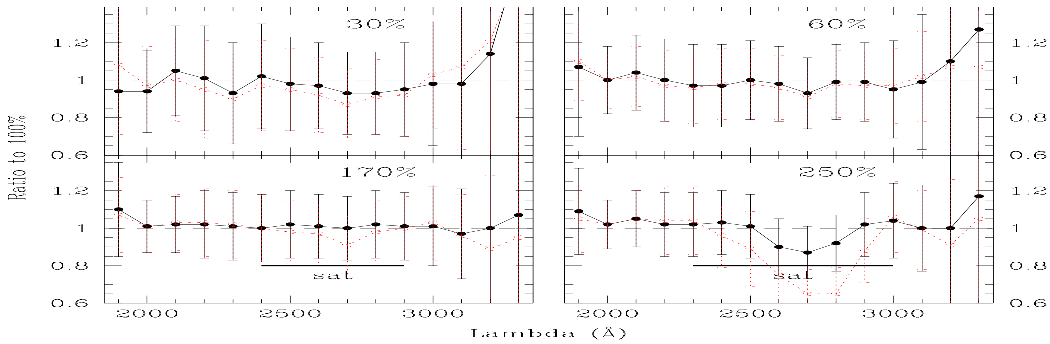

Figure 3: *Same as Figure 1, for the LWR(ITF-B) camera.*

underexposed spectra. Linearity remains within ± 5% for exposure levels above 60%. The most linear bands are those centered at 2500, 2900 and 3100 Å. In the saturated part of the most overexposed spectrum, the flux is underestimated by approximately 10%. However, the flux is correctly derived in the case of the 170% spectrum, which is also saturated.

4 CONCLUSIONS

Non-linearities remain in the IUE extracted spectra even after applying the Photometric Correction. Differences between the two extraction procedures (SWET and INES) are small, although INES results are slightly better for non-saturated spectra. In the non-saturated data, the largest departures from linearity are generally found at the edges of the spectral range in the underexposed spectra. In the central parts of the cameras linearity is within a ± 5 %, except in the case of saturation, where the three cameras have different behaviour. While in the SWP and LWP cameras the flux in the saturated regions tends to be overestimated, in the LWR camera it is underestimated.

References

Garhart, M.P., Smith, M.A., Levay, K.L., Thompson, R.W., 1997, *'International Ultraviolet Explorer New Spectral Image Processing Information Manual–Version 2.0'*, see INES Document 3.2.7

Dravins, D., Linde, P., Fredga, K., Gahm, G.F., 1993, ApJ 403, 396

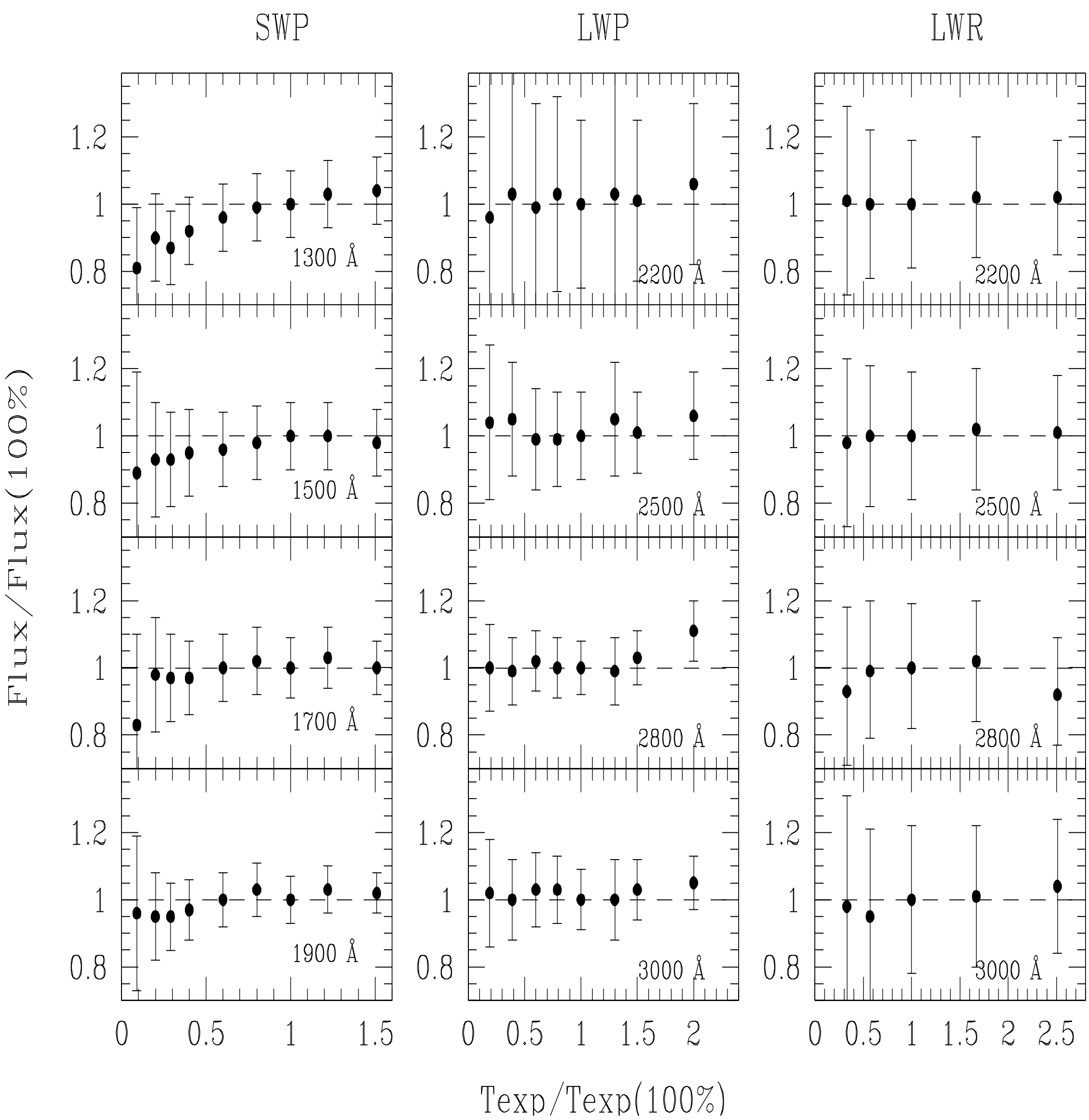

Figure 4: *Linearity characteristics of different spectral bands in each camera (INES extraction). Four bands are shown in each case, two at the center of the camera and two at the edges.*