SCIENCE VERIFICATION OF THE IUE FINAL ARCHIVE DATA PRODUCTS

D. Massa[1], M.E. Van Steenberg[2], N. Oliversen[1],P. Lawton[1]
[1]Hughes STX
[2]NASA/GSFC

ABSTRACT

We have tested the temporal behavior and overall scientific quality of *Final Archive* (NEWSIPS) extracted spectra (MXHI and MXLO files). We utilized 1859 low and 541 high dispersion, well exposed large aperture spectra of 6 *IUE* standards to perform the tests. Among other results, we find that the low dispersion LWR data contain sizable temporal effects ($\sim 10\%$) and that even the latest version of the SWP spectra still contain residual time dependence shortward of Ly α. We also demonstrate that the NEWSIPS error model systematically under estimates the actual standard deviation by a small amount and draw attention to recent results which show a 10-15% discrepancy between the NEWSIPS and *HST*/FOS absolute flux calibrations. However, the largest inconsistencies are time dependent effects seen in extracted high dispersion spectra. NEWSIPS SWP spectra of the same object obtained 12 years apart, can disagree by as much as 40% at the shortest wavelengths, and by 10-15% at most other wavelengths. We demonstrate that this effect is introduced by the processing and that it was not present in the original, IUESIPS data. The LWP data display a similar, but quantitatively smaller effect. These results underscore the necessity of making the unextracted data products easily accessible, so that users can apply customized extractions as warranted.

Key words: *IUE*, data analysis, NEWSIPS.

1. INTRODUCTION

As part of archiving the *IUE* NEWSIPS data at the Space Science Data Operations Office (SSDOO), we are performing a number of science verification activities in conjunction with the *IUE*/NASA project. The verification is especially important for NEWSIPS data since they were generated specifically for the archive and have not been thoroughly examined by the user community.

To date, our investigations have concentrated on **extracted, untrailed, large aperture data** from all cameras in low dispersion and the SWP and LWP in high dispersion. Section 2 describes the low dispersion results, §3 presents the high dispersion analysis, and §4 is a summary.

The analysis is performed on the *IUE* standard stars listed in Table 1 (Pérez et al. 1990) using standard IUEDAC software. The Table lists the star name, spectral type, photometry, and the number of well exposed NEWSIPS spectra used in the analyses of both low and high dispersion data.

2. LOW DISPERSION DATA

We examined the time dependence of 237 well exposed, untrailed large aperture LWR NEWSIPS spectra of the 3 low dispersion calibration standards in Table 1. Spectra for each standard were normalized by their mean and then interleaved with the other standards in time. We then constructed the grey scale representation of the data shown in Figure 1 for data obtained between 1978 and 1984, the time period when the LWR was the default long wavelength camera. Inspection of the grey scale shows a clear time dependence in the data for *all* the standards, with data from early in the mission having larger flux values.

Figure 2 shows this time dependence integrated over the wavelength band $2400 < \lambda < 2800$Å. Each point is the mean flux across the band normalized by the mean value for that star. It is clear that flux values for the same source change by roughly 10% between 1978 and 1984.

We also examined the time dependence of 930 well exposed, untrailed large aperture SWP NEWSIPS spectra of the 3 low dispersion calibration standards listed in Table 1. We found that even the most recent NEWSIPS spectra (version 2.5.2 for low dispersion) still contain some residual time dependence shortward of Ly α (up to 10% near the end of the mission). Grey scale plots of the SWP data also showed that the wavelength alignment is inconsistent, changing with time at the shortest wavelengths. However, wavelength calibration has always been problematic for $\lambda < 1250$ Å, due to a paucity of calibration lines.

We next turned our attention to the veracity of the modeled standard deviations provided in the MXLO files. For each of the low dispersion standards listed

Table 1. IUE Standard Stars

Low dispersion standards						
Name	Sp Ty	V	B-V	LWR	LWP	SWP
HD 60753	B3 IV	6.69	-0.09	80	240	310
BD+75^{o}325	sdO	9.54	-0.37	80	238	295
BD+28^{o}4211	sdO	10.52	-0.33	77	214	325
High dispersion standards						
ζ Cas	B2 IV	3.66	-0.20	-	98	100
η UMA	B3 V	1.86	-0.19	-	110	162
τ Sco	B0 V	2.82	-0.25	-	-	71

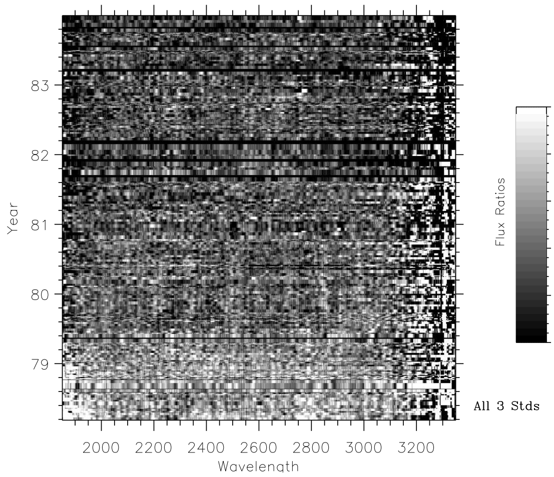

Figure 1. Time dependence of 237 LWR NEWSIPS spectra of the 3 low dispersion standards in Table 1. Each standard is normalized by its mean and then interleaved in time. The data were placed on a linear time grid using nearest neighbor interpolation, with dark gaps appearing whenever 30 days past between spectra.

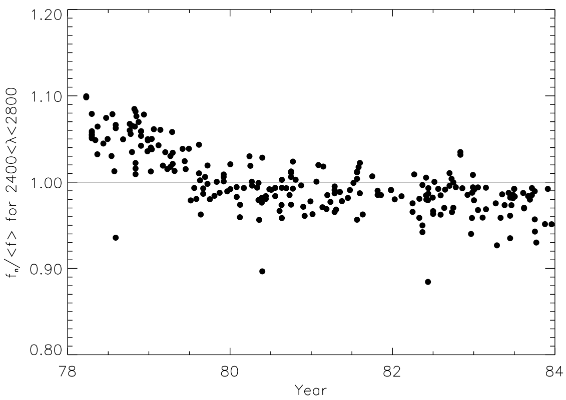

Figure 2. Plot of LWR fluxes across the band $2400 < \lambda < 2800 Å$*. Each point is the mean flux across the band for a star normalized by the mean value for that star.*

in Table 1, we determined the actual standard deviations and compared these to the square root of the quadratic mean of the MXLO errors. The results are shown in Figure 3. This figure shows that; the ratios agree from one standard to the next and, the MXLO error model systematically underestimates actual standard deviations by up to 40%. However, this is not considered a very serious effect, since the relative weights agree fairly well, and the distinction between 1 and 1.4 σ is marginal in most practical situations.

We should also point out that Fitzpatrick & Massa (1998) have compared the NEWSIPS and *HST*/FOS (Bohlin 1996) absolute flux calibrations and found that they differ by as much as 15%. We emphasize that their transformation was derived from hundreds of spectra of several blue stars observed by both satellites, and that it is not known whether it applies to objects with very different energy distributions.

3. HIGH DISPERSION DATA

This section presents our analysis of the high dispersion NEWSIPS extracted spectra (MXHI files). This analysis uncovered a number of anomalies. Figure 4 shows the time dependence of 71 large aperture high dispersion NEWSIPS MXHI spectra of τ Sco. Several aspects of the figure are worth noting:

1. Strong lines (e.g., the C III $\lambda\lambda$ 1175 multiplet, interstellar Ly α, and N V $\lambda\lambda$ 1238-42) all grow stronger with time.
2. The regular pattern appearing in the figure is the echelle ripple, where regions with low flux in the unripple-corrected spectra become even lower (darker) as time passes and regions with high flux get stronger (lighter).
3. The flux in the core of the saturated interstellar Ly α line is not zero, as it should be, in the mean spectrum.

Points 1 and 2 suggest a time dependent effect which depends on the flux level of the unextracted spectra. Point 3 indicates that low fluxes are overestimated at the beginning of the mission.

Figure 5 examines the temporal dependence more quantitatively, by comparing the total observed

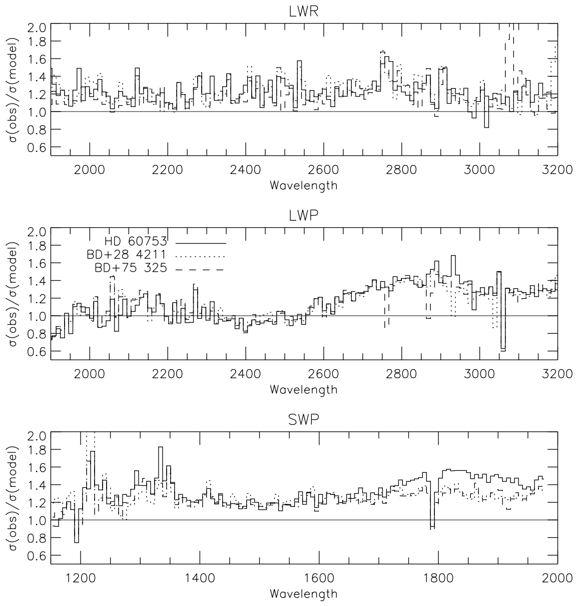

Figure 3. Ratios of observed to MXLO modeled standard deviations for the low dispersion standards listed in Table 1. All 3 standards are overplotted, with line styles given by the key.

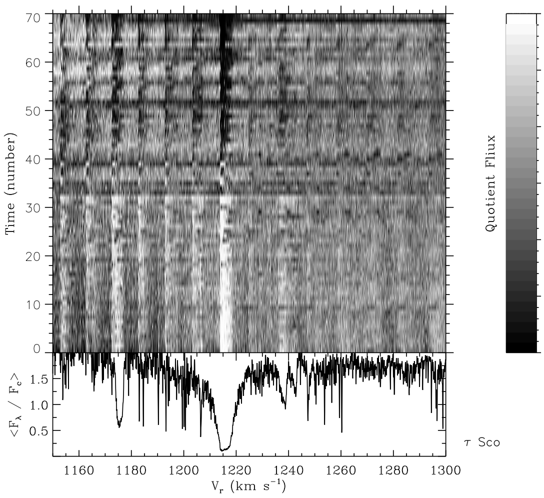

Figure 4. Time dependence of 71 SWP high dispersion NEWSIPS MXHI spectra of τ Sco obtained over the lifetime of IUE – only the short wavelength region is shown. The spectra are normalized by their mean and the temporal ordinate is simply the accumulated number of spectra.

changes in η UMa and ζ Cas. This plot demonstrates the following points:

1. The structure of the two ratios is identical, implying that it is a property of the processing and not the stars.
2. The ripple pattern in the NEWSIPS spectra implies that spectra obtained 12 years apart differ by 10% on average and up to 30–40% shortward of Ly α.
3. The systematic structure in the spectra is far greater than the random noise. Therefore, systematic effects determine the ultimate accuracy of comparisons between spectra obtained at different epochs.

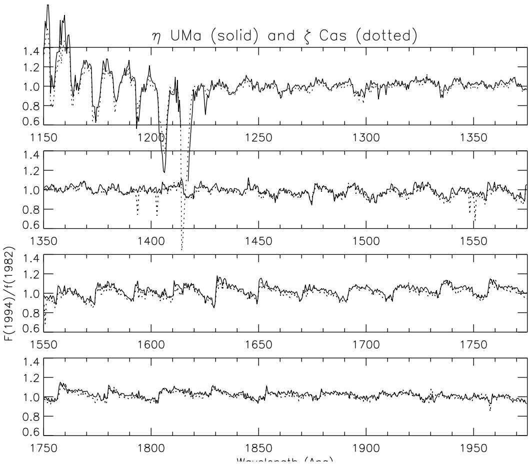

Figure 5. Time dependence of SWP NEWSIPS large aperture extractions of η UMa (solid) and ζ Cas (dotted). The curves are ratios of 10 spectra means from 1993-94 divided by 10 spectra means from 1981-82 for each star (all binned to 0.5 Å/point).

Figure 6 Compares the time dependence of SWP NEWSIPS (solid) and the original IUESIPS (dashed) extractions of large aperture spectra of η UMa. The ripple pattern in the NEWSIPS spectra is the same as in Figure 5. The IUESIPS data do not have this problem, but they do show the signature of instrumental degradation, which was not accounted for in IUESIPS processing. This figure demonstrates that whatever the cause of the ripple pattern in the NEWSIPS data, it was not present in the older extractions.

In the process of analyzing the data, we also noticed the following general anomalies in MXHI extracted spectra:

- In very blue objects, the flux in the core of saturated interstellar Ly α (which should be zero) can be as large as 10% of the continuum.
- In certain B supergiants, the flux in the cores of the strong C IV $\lambda\lambda$ 1550 wind lines can be negative by as much as 10% of the continuum.

We next examined the time dependence of high dispersion LWP NEWSIPS data. Figure 7 is a grey scale of 110 LWP NEWSIPS large aperture high dispersion extractions of η UMa. As in Figure 4, the echelle ripple pattern is apparent, except at a lower level.

Figure 8 displays the LWP time dependence of ζ Cas (solid) and η UMa (dotted) spectra and is similar to

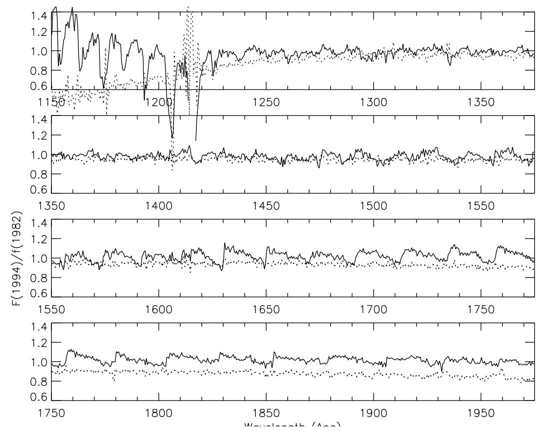

Figure 6. Time dependence of SWP NEWSIPS (solid) and IUESIPS (dashed) extractions of large aperture spectra of η UMa. Each curve is a ratio of a 10 spectra mean obtained in 1993-94 divided by a 10 spectra mean from 1981-82 (all binned to 0.5 Å/point).

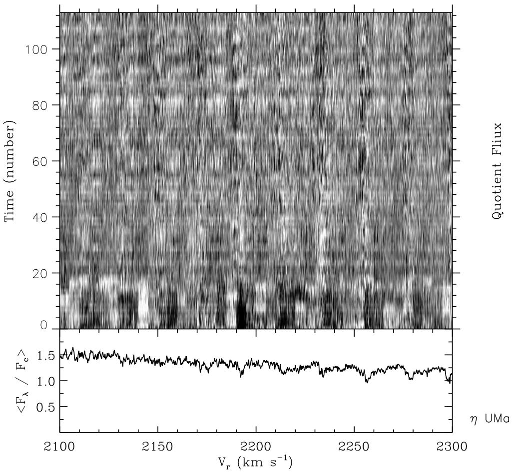

Figure 7. Time dependence of 110 LWP NEWSIPS large aperture high dispersion extractions of η UMa obtained over the lifetime of IUE. Only a portion of the wavelength coverage is shown, and the display is the same as for Fig. 4.

Figure 5 for the SWP spectra. As in Figure 5, the ripple pattern is present, but the effect is quantitatively smaller. Additionally, as in Fig. 6, the systematic effects can dominate the random noise.

4. SUMMARY

We have tested the consistency of both low and high dispersion NEWSIPS extracted spectra. The low dispersion spectra contain a few minor problems which should be fairly easy to correct for by applying simple corrections to the extracted data. On the other

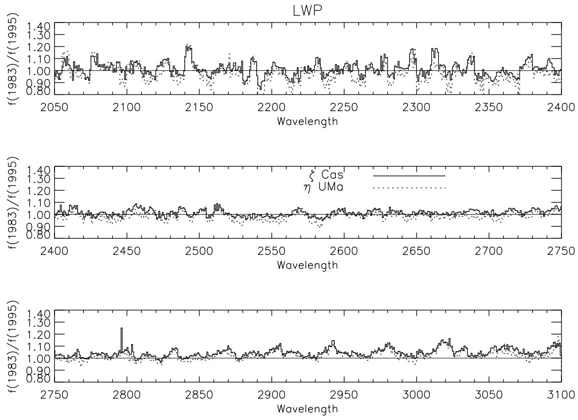

Figure 8. Time dependence of LWP NEWSIPS large aperture extractions of ζ Cas (solid) and η UMa (dotted). The curves are ratios of 10 spectra means from 1993-94 divided by 10 spectra means from 1981-82 for each star (all binned to 0.5 Å/point).

hand, the high dispersion spectra contain some serious systematics which may not be so easily remedied.

The high dispersion anomalies probably result from compromises needed to make the difficult process of echelle spectral extraction automated. Nevertheless, they underscore the necessity of making the unextracted data products easily accessible, so that users can apply customized extractions as warranted.

Further details and updates can be obtained from

`http://hypatia.gsfc.nasa.gov/iue/`

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