IUE DATA REDUCTION

XXIV. Implementation of New High Dispersion Software: Summary of Output Format Changes

Memo XVIII of the IUE DATA REDUCTION series (NASA IUE Newsletter No. 12, January 1981), described the introduction of the new low dispersion IUESIPS software. The present memo announces the implementation of the corresponding new high dispersion IUESIPS software (PHOTOM, SPECHI, SORTHI, and POSTHI) on November 10, 1981 at GSFC and summarizes the changes in the output products associated with the new software. Particular attention should be paid to the increased record lengths of extracted-spectrum files on Guest Observer tapes (item 6 below). This expanded record size (equal to that of the new low dispersion software) accommodates the increased number of spectrum samples produced by the new software in order to realize the full resolution capabilities of the instrument. Details of the evaluation of the new high dispersion software and a comparison with the relevant characteristics of the old software are given in memo XXV of this series.

1. There is no geometrically corrected image produced with the new software. Instead, a photometrically corrected image is produced in the original distorted readout frame of reference. The geometric distortion in the detectors is accounted for implicitly by using the reseau grid to locate the position in the raw (distorted) image for photometric correction or extraction. This procedure avoids the smoothing of the non-linear raw images in the GEOM step of the old software. The second frame of the reduced Photowrite film sheets showing the superposed dispersion overlay after spectral registration is a raw image, and the third frame is the photometrically corrected image with no geometric correction.

2. The photometric correction is performed on a pixel in the raw image by spatially interpolating within the existing Intensity Transfer Function (ITF) at the appropriate point. Pixels outside of a circular region encompassing the useful spectral data are left unchanged as raw DN values. This region is precisely circular in the geometrically corrected frame of reference, and only approximately circular in the raw-image frame of reference.

3. The coding of the halfword pixel values in the photometrically corrected image file (PI) has been changed to accommodate the more extensive flagging system for exceptional pixels, which is also used in the new low dispersion software. The coding system is such that the value of each halfword pixel F_{image} in the PI file is used to flag the special cases of extrapolation, saturation, and no photometric correction. Table 1 of memo XVIII contains the explicit relationships between true flux numbers (FN) and coded values F_{image}.

4. Gross spectra are extracted from the photometrically corrected image using a slit with a length which depends on order number for the point-source reduction mode and which is constant (10 pixels) for the extended-source reduction mode. Details are given in memo XXV.

5. Background spectra are extracted excluding reseaux, microphonic noise in LWR, or saturated pixels, as is now done in the new low dispersion software. Also, the order overlap problem is reduced as discussed in memo XXV.

6. The extracted spectrum file (referred to as MEHI) has an increased data record length of 2048 bytes, accommodating up to a total of 1022 points per order. Otherwise, the spectral data records are in the same format as before.

7. The scale-factor record ("record zero") in the MEHI file has an expanded format defined by Table 1. Note that this scale-factor record contains significantly more entries than

that generated by the old software, although neither the location nor the meaning of any previously-existing quantity has been changed. Note also that several items have been either added or more completely explained since the implementation of the expanded scale-factor record in low dispersion described in memo XVIII. Table 1 should therefore be considered to reflect the current content of the scale-factor record under the new software for both high and low dispersion; entries which are dispersion-dependent are so marked.

8. New data quality flags (epsilons) consistent with those used in the low dispersion software are defined in Table 2. Note that the epsilon value is no longer the sum of a positive term, and a negative term for special conditions, as in the old software. Also, note that if more than one of the negative-epsilon conditions occurs, the most negative flag is used. Since reseaux, microphonic noise in LWR, and saturated pixels are not used in the background determination, they are not flagged in the background on CalComp plots nor in the MEHI tape file if the gross spectrum itself is not affected.

9. Assigned wavelengths differ in two ways from those produced by the old software:

a.) Wavelengths are first reduced to a heliocentric frame of reference on the basis of the target coordinates and time of observation. The time of the midpoint of observation used for this reduction is listed in halfwords 9 - 12 of record zero (see Table 1) and in the processing history portion of the alphanumeric header label of the MEHI file; likewise, the target coordinates used are listed in halfwords 45-50 of record zero and also in the image label. The software which uses these data to calculate the velocity components of the earth and IUE in a righthanded rectangular equatorial coordinate system (+x is toward vernal

equinox, +z is toward the north celestial pole) was described in memo XVI of the IUE DATA REDUCTION series in NASA IUE Newsletter No. 10, June, 1980. These computed X, Y, Z velocity coordinates are given in both record zero (halfwords 51-56) and the image label. Finally, the actual net radial velocity correction, which is added to the extracted wavelengths to obtain the heliocentric wavelength scale, is given in halfword 57 of record zero and in the image label. A positive net radial velocity correction indicates a net approach of the IUE detector toward the target.

In the case of spectra extracted from WAVECAL images, no heliocentric correction is applied.

b.) The vacuum-to-air wavelength correction is then applied consistently in all cameras for λ (heliocentric) $\geq$ 2000Å. Previously, only data from the long wavelength spectrograph (cameras LWR and LWP) were so converted.

10. Net ripple-corrected fluxes in the MEHI file and as plotted have been filtered using the 7-point "optimal" filters discussed in memo XXV to condition the noise inherent in the raw IUE images. Furthermore, the net ripple-corrected fluxes are now set to zero at the ends of each order, i.e., when $|\lambda - \lambda_c| > (2.6 \cdot K) / mm^2$, where

K = ripple constant
m = order number
λ_c = blaze wavelength ($=K/m$) in Å
λ = wavelength in Å (before the λ corrections described above)

11. The CalComp plot of the gross and smoothed background spectra at 10 Å/inch incorporates a 2-point box filtering of adjacent extracted points to reduce plotting time and avoid paper tearing.

that generated by the old software, although neither the location nor the meaning of any previously-existing quantity has been changed. Note also that several items have been either added or more completely explained since the implementation of the expanded scale-factor record in low dispersion described in memo XVIII. Table 1 should therefore be considered to reflect the current content of the scale-factor record under the new software for both high and low dispersion; entries which are dispersion-dependent are so marked.

8. New data quality flags (epsilons) consistent with those used in the low dispersion software are defined in Table 2. Note that the epsilon value is no longer the sum of a positive term, and a negative term for special conditions, as in the old software. Also, note that if more than one of the negative-epsilon conditions occurs, the most negative flag is used. Since reseaux, microphonic noise in LWR, and saturated pixels are not used in the background determination, they are not flagged in the background on CalComp plots nor in the MEHI tape file if the gross spectrum itself is not affected.

9. Assigned wavelengths differ in two ways from those produced by the old software:

a.) Wavelengths are first reduced to a heliocentric frame of reference on the basis of the target coordinates and time of observation. The time of the midpoint of observation used for this reduction is listed in halfwords 9 - 12 of record zero (see Table 1) and in the processing history portion of the alphanumeric header label of the MEHI file; likewise, the target coordinates used are listed in halfwords 45-50 of record zero and also in the image label. The software which uses these data to calculate the velocity components of the earth and IUE in a righthanded rectangular equatorial coordinate system (+x is toward vernal

The information contained herein, along with that pertinent to the new low dispersion software, will be incorporated into a Version 2.0 of the IUE Image Processing Information Manual. The present summary is designed simply to identify changes in the format and significant content of output products.

B. Turnrose
R. Thompson
R. Bohlin

TABLE 1

FORMAT OF RECORD ZERO
(scale factor record)

ITEM (16-bit halfword)		QUANTITY
1	*	Zero (For Record #0)
2	*	Number of points in record (now 1022)
3	*	Minimum Wavelength (truncated to nearest Å)
4	*	Maximum Wavelength (rounded to nearest Å)
5	*	Number of orders present
6	*	Camera Number
7	*	Image Number
8	*	Number of records per group (i.e. per order)
9		Year
10		Day Number } - of Midpoint of
11		Hour } Observation (GMT)
12		Min
13-16		Date as above for Time of Image Processing (GMT)
17		Target Aperture (1-large, 2-small)
18		Total line shift (pixels x 1000)
19		Total sample shift (pixels x 1000)
20	***	THDA X10 (°C) used for reseau correction (normally at the time of read)
21	*	Minimum FN for Gross
22	*	Maximum FN for Gross
23	*	J for Gross } where actual $\frac{FN}{2^K}$ ≡ data on
24	*	K for Gross } Tape x J x 2^{-K}
25-28	*	as in 21-24 for Background
29-32	*	as in 21-24 for Net
33-36	*	as in 21-24 for Absolute Net
37-41	*	Spares
42-44		Min, sec, ms of exp in Target Aperture (not implemented)
45		Hours } - Right Ascension
46		Minutes } of Target
47		Seconds x 10 }
48		Degrees } - Declination
49		Arc Minute } of Target
50		Arc Second }
51-53	**	VX_{earth}, VY_{earth}, VZ_{earth} - Velocity of earth in celestial coordinates (km/s x 10)
54-56	**	VX_{sat}, VY_{sat}, VX_{sat} - same as 51-53 for IUE at Midpoint of Exposure
57	**	Net velocity correction applied (km/s x 10)

---

* Existing Quantity under old software.

** High Dispersion Only

*** Not used to correct reseau positions for the LWR or LWP cameras

FORMAT OF RECORD ZERO
(continued)

ITEM		QUANTITY
58		Omega angle (degrees x 10)-(zero in High Dispersion)
59		Wavelength Scaling Factor (=5 for Low Dispersion, = 500 for High Dispersion) where actual λ = (λ on tape)/(Scale Factor) + λ_0
60		Background Slit Height } - Low Dispersion only (pixels * 100).
61		Background distance from dispersion line }
62		Dispersion Constant Shift (0 = no shift, 1 = auto shift, 2 = manual shift)
63		Bright Spot Removal Threshold DN for weak, long exposures (to be implemented)
64	****	THDA x 10 for dispersion constant correction (normally at the time of the end of exposure)
65-70	*	Spares
71-102		For use of IUE Regional Processing Centers
103-202*		λ_0, offset wavelengths for each order
203-302*		m, order number for each order
303-402*		Number of extracted data points in each order
403-502		Slit height for each extracted order (pixels*100)
503		Sign + First 4 digits after decimal of dispersion constant A1
504		Sign + Second set of 4 digits after decimal of dispersion constant A1
505		Sign + Third 4 digits after decimal of dispersion constant A1
506		Exponent (including Sign) of dispersion constant A1 where: A1 = [item(503)x10^{-4}+ item(504)x10^{-8}+ item(505)x10^{-12}]x10** (item(506))
507-510		As above, for dispersion constant A2
511-538		As above, for dispersion constants A3 through A9
539-574		As above, for dispersion constants B1 through B9
575-1024		Spares

---

* Existing Quantity

**** Currently not used to correct dispersion constants for the LWP camera

TABLE 2

Data Quality Flags (Epsilons)

Epsilon	Condition
100	No special conditions
-200	Extrapolated ITF
-220	Microphonic noise
-250	Filtered bright spot *
-300	Unfiltered bright spot *
-800	Reseau in spectral extraction region
-1600	Saturated pixel or maximum ITF extrapolation
-3200	Pixel outside target ring (low dispersion line-by-line file (LBLS) only)

* Feature to be implemented in the future, to flag bright-pixel artifacts.