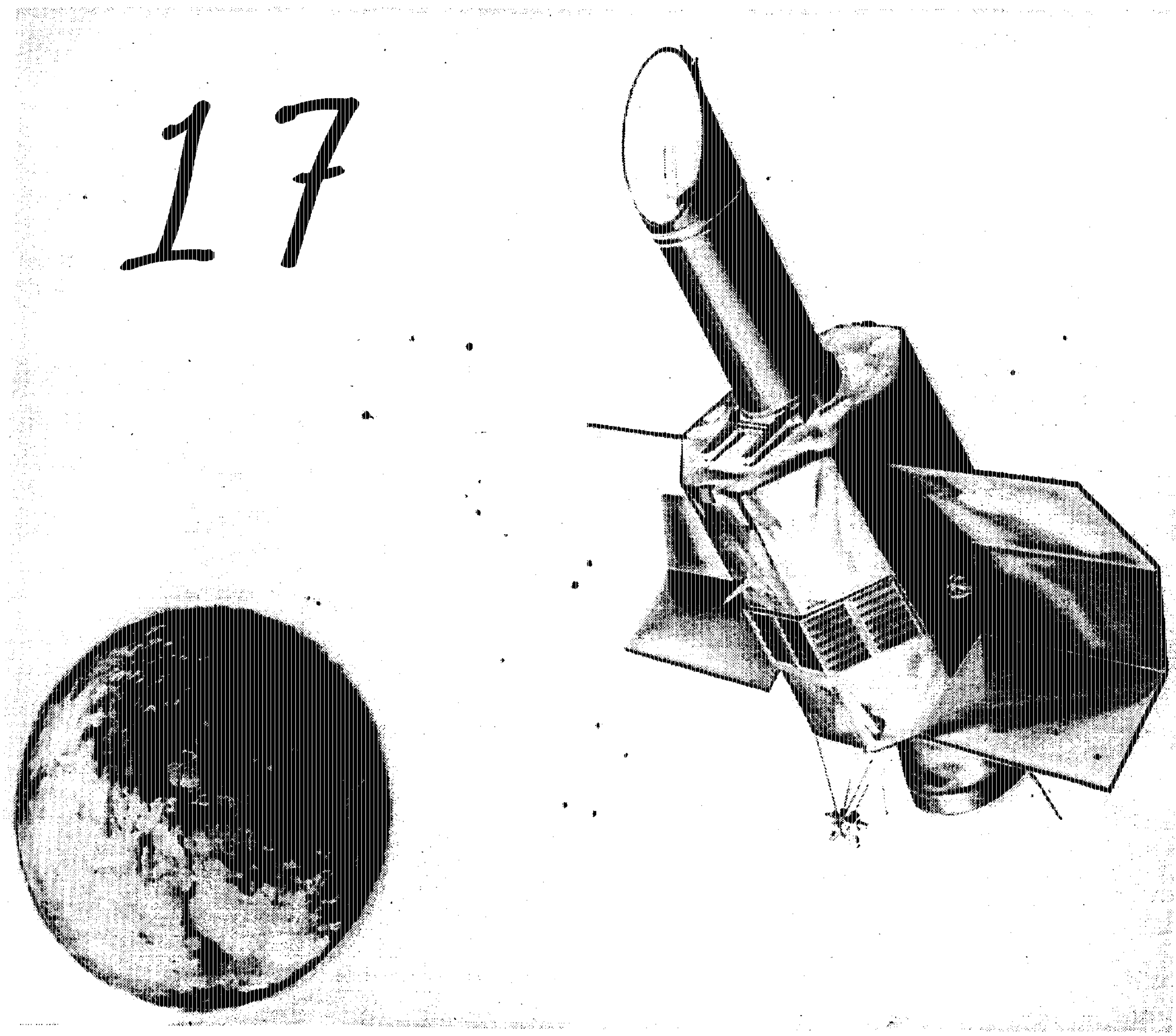
International Ultraviolet Explorer (IUE)

NASA NEWSLETTER



National Aeronautics and
Space Administration

Goddard Space Flight Center
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NASA NEWSLETTER FOR

INTERNATIONAL ULTRAVIOLET EXPLORER (IUE)

NO. 17

Dear Colleagues:

This is a special issue of the Newsletter containing "Techniques of Reduction of IUE Data: Methods for Improving Previous IUESIPS Tape Products" prepared by B.E. Turnrose, C.A. Harvel, and A.D. Mallama. A companion volume containing the related document "Techniques of Reduction of IUE Data: Time History of IUESIPS Configurations" is being issued as Newsletter No. 16.

As usual, Dr. P. Perry and Mona Cooper provided the essential support in preparation of this Newsletter.

Cordially,

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TECHNIQUES OF REDUCTION

OF IUE DATA:

METHODS FOR IMPROVING PREVIOUS IUESIPS TAPE PRODUCTS

By

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ABSTRACT

This document presents a compilation of methods of correcting for the inhomogeneity of International Ultraviolet Explorer (IUE) reduced data products on tape. It is a companion volume to CSC/TM-81/6117, Techniques of Reduction of IUE Data: Time History of IUESIPS Configurations, which contains a detailed description of the evolution of the IUE Spectral Image Processing System (IUESIPS). The present document describes, wherever it is feasible to do so, the algorithms which may be applied to IUE data reduced under the various configurations catalogued in CSC/TM-81/6117 in order to bring older data up to current IUESIPS standards. It is expected that this information will be of particular utility to the designers and users of the IUE Regional Data Analysis Facilities.

This document is a reprint of CSC/TM-81/6136, issued in October 1981 under the same title.

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SECTION 1 - INTRODUCTION

1.1 BACKGROUND

The International Ultraviolet Explorer (IUE) satellite has been in operation as a Guest Observer facility since April 3, 1978. The software system used by the IUE Observatory ground stations at GSFC and Villafranca del Castillo, Spain (VILSPA) to perform the standard IUE data reduction operations and generate the standard output products, the IUE Spectral Image Processing System (IUESIPS), has undergone a continual evolution since April 1978 in order to enhance the quality of the data processing and remove various software deficiencies and errors as they were discovered. As a result of the various changes made to IUESIPS, there is necessarily an inhomogeneity between data as it would be processed currently and the same data as it might have been processed at prior times. The document CSC/TM-81/6117, Techniques of Reduction of IUE Data: Time History of IUESIPS Configurations, describes in considerable detail this evolution of IUESIPS and its ramifications. Emphasis in that document is placed on allowing the Guest Observer or archive user to assess the inhomogeneity of IUE data reduced at diverse times at either ground station (GSFC or VILSPA) between April 3, 1978 and March 31, 1981; this is achieved by presenting detailed descriptions of the IUESIPS configurations in place at both ground stations during this period.

1.2 OBJECTIVES

The purpose of this document is to complement CSC/TM-81/6117 by providing instructions, in the form of explicit algorithms wherever possible, for correcting or enhancing previously-processed IUE data in order to bring those data up to the standards currently (April 1981) achieved by IUESIPS. The time history of IUESIPS configurations presented in CSC/TM-81/6117 provides the framework for the correction methodologies contained herein. The primary goal is to provide sufficient information to allow a programmer to implement corrective software which can be applied to reduced data products generated under each configuration discussed in CSC/TM-81/6117. A secondary but nearly as important goal is to identify those past configurations for which algorithmic corrections are either inappropriate or infeasible.

1.3 SCOPE

This document addresses each IUESIPS production configuration cataloged in CSC/TM-81/6117. As such, it relates to IUE data on magnetic tape processed between April 3, 1978 and March 31, 1981 at either ground station and obtained from either ground station as original Guest Observer data or from one of the various international data centers as archive data.

Because the primary goal of this document is to provide instructions to programmers for coding correction algorithms, as much explicitly detailed information as was deemed useful has been included in the discussion of the methods of upgrading data processed under each configuration. Such information takes the form of equations, detailed explanations, and cross references to easily available existing pertinent documentation wherever possible.

Those configurations for which it is not possible or advisable to define ex post facto corrections for extracted spectral data are so identified. In some instances, re-extraction of spectral data from the existing photometrically corrected image is the only suitable means of upgrading the data; in other instances, complete reprocessing from the raw-image stage is the only suitable means of correction. In such cases, our discussion is limited to a presentation of pertinent considerations and cautions (for example, array sizes, special requirements and the like) which would apply to any attempt to code and implement software to perform these large calculations.

Since such large-scale computational tasks are beyond the planned scope of the IUE Regional Data Analysis Facilities and most individual users' institutional facilities, this limitation is appropriate. Finally, certain instances in which corrections are not applicable are so identified.

SECTION 2 - CORRECTION METHODOLOGY

2.1 GENERAL CONSIDERATIONS AND OVERVIEW

The approach taken in this document is to simplify the user's task of applying corrective algorithms to previously reduced data by modularizing the presentation of those algorithms. In so doing we have isolated particular procedures or methods of general applicability and presented them once in Appendix A. Thereafter, in discussing specialized procedures unique to given IUESIPS configurations, the general-purpose methods are invoked, as needed, by reference to the Appendix. Such an approach eliminates much unnecessary repetition and streamlines the presentation.

Furthermore, emphasis is placed on algorithms by which extracted spectra may be made compatible with current data, since such algorithms are generally within the reach of modest computational facilities. Instances where the entire two-dimensional image data arrays (either raw or photometrically corrected) must be manipulated to correct a problem (as in complete reprocessing or spectral re-extraction), are, as mentioned in section 1.3, treated only in general terms. In section 2.2 an index is provided in tabular form to allow quick review of the recommended correction methods for each of the IUESIPS configurations addressed in CSC/TM-81/6117. Only those configurations identified in section 2.2 as having relevant algorithmic corrections or otherwise requiring special instructions are discussed in section 2.3.

Several general remarks are in order about assumptions that have been made regarding the use of the correction procedures presented in this document. It is first of all assumed that the user has familiarized himself with existing documentation on IUE data and data reduction techniques and has a reasonable knowledge of the major steps in the reduction of IUE data and their logical connection. Useful references in this regard are Perry and Turnrose (1977), Klinglesmith, Perry, and Turnrose (1979), Lindler (1979a,b), Turnrose and Harvel (1980), the series of articles on IUE Data Reduction in the NASA IUE Newsletter (see Appendix B), and of course the companion document to this volume, CSC/TM-81/6117.

In the actual correction procedures themselves, it is assumed that data read in from tape are already converted to real-number format and that conversion back to the scaled-integer tape format will be done when the data manipulations are completed; algorithm 12 of Appendix A addresses this format conversion but is not explicitly invoked in each correction procedure.

It is also to be understood that the user must decide which aspects of the general-purpose methods presented in Appendix A are pertinent to the application at hand. For example, if the smoothing algorithm (algorithm 7) is invoked, the user must determine whether to use a double running average filter or a median-plus-double-running-average filter, depending on the particular situation (namely the date of original processing and the user's wishes). In the same way, it should be understood that the corrections bulleted out in each configuration-unique procedure in section 2.3, by nature, do not necessarily lead to an output product equivalent to that produced by the current IUESIPS software, since the correction addresses a particular configuration only, and several further stages of correction may be necessary to reach current standards. That is, the configurations are in a sense cumulative and the corrections should be considered sequentially to arrive at current standards.

2.2 INDEX TO CONFIGURATION CORRECTIONS

Each of the IUESIPS configurations cataloged in CSC/TM-81/6117 is listed by number and title in Table 2-1, where the various

Table 2-1. INDEX TO CONFIGURATION CORRECTIONS

Number	Title	Alg.	Re-ext.	Repro.	N/A
1.	Corrupted data at the ends of smoothed background spectra (and hence net spectra).	X			
2.	Restricted low dispersion SWP wavelength coverage (λ1000-1900Å).		X		
3.	Erroneous negative fluxes in extracted spectra due to incorrect integer scaling of Fmax.	X			
4.	Non-optimal center and radius values for circle in which geometric correction is performed.			X	
5.	Suppression of redundant wavelengths in high dispersion processing.		X		
6.	Unrestricted RIPPLE correction at ends of orders in high dispersion.	X			
7.	Reversed naming convention for dispersion constants as written in IUESIPS history label.				X
8.	No processing dates written in IUESIPS history labels.				X
9.	One-pixel error in OSCRIBE (dispersion-constant overlay program).	X	X		
10.	Nearest-neighbor line-finding algorithm in WAVECAL.		X		
11.	Use of ITF's composed of single exposures.			X	
12.	Accomplish registration of spectral orders with dispersion-constant overlays by shifting the images (rather than the dispersion constants).		X		
13.	Extraction of low dispersion spectra using the programs SPIN, ROTATEH, and COMPARE.		X		
14.	Epsilon-field values in smoothed backgrounds shifted to incorrect wavelengths.	X	X		
14.1	Dispersion constant and reseau calibrations used for VILSPA reductions (1).	X	X	X	
14.2	Error in long wavelength high dispersion wavelengths.	X			
15.	Reseau flagging in low dispersion merged spectra does not distinguish between reseau mark in gross spectrum and reseau mark in background spectrum.	X	X		
16.	Geometric correction of high dispersion images accomplished using reseaux measured on high dispersion WAVECAL images.			X	

Number	Title	Alg.	Re-ext.	Repro.	N/A
17.	Use of non-optimal RIPPLE parameters for LWR.	X			
18.	Extract low dispersion spectra (EXTLOW) with HT=9 and DISTANCE=8.0 (Will not properly extract spectra of aperture-filling objects).	X	X		
19.	Image sequence number sometimes zeroed out in scale factor record of merged spectral file.	X			
20.	Determine LWR low dispersion wavelength calibrations from preliminary version of line library.				X
21.	Use of incorrect offsets from small to large aperture in LWR.	X			
21.1	Error in SWP low dispersion wavelength scale.	X			
22.	Perform all registrations of spectral orders with dispersion-constant overlays manually.		X		
23.	Camera number transmitted as true number plus 10 or 20 in scale factor record of merged spectral file.	X			
24.	Determine SWP low dispersion wavelength calibrations from preliminary version of line library.	X			
25.	Extract low dispersion large-aperture point-source spectra with DISTANCE=8.0.	X	X		
26.	Improper truncation of area of image photometrically corrected.			X	
27.	Automatic registration of spectral orders done using only 6 sampling areas in DSPCON.		X		
28.	Omit vacuum-to-air correction for LWR low-dispersion single-aperture reduction.	X			
29.	Photometrically correct entire 768 x 768 image (SWP high dispersion).				X
30.	Photometrically correct entire 768 x 768 image (low dispersion).				X
31.	No information on values of OMEGA, HBACK, or DISTANCE in IUESIPS history labels.				X
32.	No information on values of automatic registration shifts recorded in IUESIPS history labels.				X

Table 2-1 continued

Number	Title	Alg.	Re-ext.	Repro.	N/A
33.	Process order 65 in SWP high dispersion.				X
34.	Photometrically correct entire 768 x 768 image (LWR high dispersion).				X
34.1	Dispersion constant and reseau calibrations used for VILSPA reductions (2).	X	X	X	
34.2	Dispersion constant and reseau calibration used for VILSPA reductions (3).	X		X	
35.	Use incorrect version of ETOEM.		X		
36.	High dispersion partial processing on S/360 (VICAR).				X
37.	Use original IUESIPS File Management System.				X
38.	No information on values of manual registration shifts recorded in IUESIPS history label.				X
39.	No output products generated for images designated "Do Not Process".				X
40.	Improperly convert certain spectral files with negative fluxes to GO-tape integer format.	X	X		
41.	All high dispersion extractions done with HT=5.		X		
42.	Write redundant raw-image tape files for wavelength calibration images.				X
43.	No short header file written at beginning of GO tape.				X
44.	Use of SWP ITF with incorrect 20% exposure level.	X		X	
45.	Use of non-optimal pixel offsets from small to large aperture.	X			
46.	Use of pixel offsets from small to large aperture which do not correspond to physical center of large aperture.				X
47.	Write geometrically-correct-image tape file for wavelength calibration images.				X
48.	Use biweekly dispersion-constant calibrations in low dispersion.	X			
49.	Determine high dispersion wavelength calibrations from unrefined line libraries (version I Libraries).				X
50.	Do not provide absolutely calibrated net spectrum in low dispersion.	X			
51.	Truncation of ITF at upper limit.			X	

Table 2-1 continued

Number	Title	Alg.	Re-ext.	Repro.	N/A
52.	Incorrect units for DISTANCE parameter in EXTLOW.	X	X		
53.	Use original *Astron. Astrophys.* absolute calibration.	X			
54.	Determine high dispersion wavelength calibrations from partially refined line libraries (version II libraries).				X
55.	Use biweekly reseau calibrations.			X	
56.	Use biweekly dispersion constant calibrations in high dispersion.		X		
57.	Use preliminary mean dispersion constants for low dispersion.	X			
58.	Inaccurate automatic registration programs.	X	X		
59.	Determine high dispersion wavelength calibrations from further refinements to line libraries (version III libraries).				X
59.1	Incorrectly transmit 5-digit image sequence numbers to scale-factor record of extracted spectral files.	X			
60.	Processing of low dispersion spectra using the programs GEOM, FICOR, and EXTLOW.	X		X	
61.	Non-perpendicular manual shifts (REGISTER).	X			
62.	Label lacks scheme name and auto/manual message.				X
63.	Incorrect manual shift for SWP images (REG).	X			
64.	VBBLK without label processing.	X			
65.	Incorrect entries in label by SPECLO (negative declination and zero shift).	X			
66.	Inaccurate automatic registration (LWR-LOW, SWP-HIGH and all Trailed)		X		
67.	Calibration files without temperature corrections (low dispersion).	X	X	X	
68.	Use of preliminary parameters to specify the region to be processed by the program PHOTOM.			X	
69.	Use positional information to determine the bounds of the area to be extracted (SPECLO).				X
70.	Unused lines of header label not blank-filled by POSTLO.				X
71.	Dispersion constant and reseau calibrations used for VILSPA reductions (4).	X	X	X	

applicable approaches to correcting each configuration are indicated by an "X" in one or more of the appropriate columns headed "Alg.", "Re-ext.", "Repro.", and "N/A". A mark in the "Alg." column indicates that an algorithm has been defined to correct the extracted spectral data and is included in section 2.3. A mark in the "Re-ext." column indicates that re-extraction of spectral data from the photometrically corrected image is required and that the user is referred to algorithm 2 of Appendix A for further information. A mark in the "Repro." column indicates that complete reprocessing of the image from its raw form is required and that the user is referred to algorithm 1 of Appendix A. A mark in the "N/A" column indicates that a correction procedure is not applicable for the particular configuration so marked.

Note that it is possible for a configuration to carry a mark in more than one column of Table 2-1, which means either that two alternative approaches to the correction have been identified or that certain aspects of the data can be corrected in one manner while other aspects require a different method. In such instances, further explanation is provided in Section 2.3. Note again that only those configurations marked in the "Alg." column of Table 2-1, or those for which special instructions for re-extraction/reprocessing are required, are addressed in section 2.3.

2.3 CORRECTION PROCEDURES

2.3.1 General-Purpose Procedures

A total of 14 general-purpose data manipulation/correction methods have been defined. These methods are outlined by number and title in Table 2-2 and represent procedures which must be invoked by many of the individual configuration-unique correction procedures to be presented in section 2.3.2. Because of their general and repeated usage, these procedures are presented separately in Appendix A and simply cross-referenced elsewhere in the document by number as necessary.

Table 2-2 General-Purpose Correction Procedures

Algorithm Number	Title
1	Complete reprocessing
2	Spectral extraction from photometrically corrected image
3	Pseudo-slit extractions from line-by-line spectra
4	Wavelength assignments via dispersion constants
5	Low-dispersion wavelength corrections
6	Wavelength corrections for zero-point shifts
7	Background smoothing
8	Ripple correction
9	Vacuum-to-air wavelength correction
10	Absolute calibration
11	Scaling fluxes and wavelengths from integer to real format and vice versa
12	Updating scale-factor record of extracted spectra
13	Updating IUESIPS history labels
14	Reading THDA values from IUESIPS label

2.3.2 Configuration - Unique Procedures

In this section the correction procedures for each of the configurations marked in the "Alg." column of Table 2-1 are presented. Additionally, in this section are included entries for configurations whose correction procedures require special instructions or information prior to re-extraction or reprocessing, even though a true algorithmic correction method has not been identified in Table 2-1.

Attempts have been made to keep the description of these procedures as concise as possible, and so certain "understood" procedures such as integer-to-real-number and real-number-to-integer conversion are not invoked explicitly (see section 2.1). References to any of the general-purpose algorithms mentioned in section 2.3.1 and detailed in Appendix A are made by algorithm number.

The user is reminded that the application of the steps comprising any one of these procedures may not by themselves yield outputs equivalent to those produced by the current IUESIPS. Instead, the resulting data may represent an intermediate stage, inasmuch as the corrections effected refer to a particular system configuration. Several successive corrections may be required, depending on the circumstances, to reach current output standards. We have attempted to provide the user with the necessary tools and information to perform each correction and have left it up to each user to decide when corrections should be combined, concatenated serially, or just considered individually, according to that user's own needs.

As an aid to the user, the configurations listed in Table 2-1 have been categorized by generic tape in Table 2-3. With this cross reference, the user may more easily decide which configurations (and hence corrections) concern various major aspects of the data. In certain cases, configurations are listed under more than one topic when it was felt important to highlight more than a single aspect. Table 2-3 should also assist users in identifying the cumulative or serial nature of the configurations.

Table 2-3 Cross-Reference of Configurations by Major Topic

	Topic	Configuration Numbers
1.	Absolute calibration	50,53
2.	Dispersion constants/reseaux (i.e., wavelengths and geometric correction)	10,14.1,14.2,16,20,21,21.1,24,34.1, 34.2,45,46,48,49,54,55,56,57, 59,67,71
3.	Extraction slit geometry	13,18,25,52,60 (low dispersion) 41 (high dispersion)
4.	Integer flux scaling on tape	3,35,40
5.	Intensity Transfer Functions (ITF)	11,44,51
6.	Label/scale record	7,8,19,23,31,32,36,38,59.1,62, 64,65,70
7.	Registration of spectral orders	9,12,22,27,32,38,58,61,63,66
8.	Ripple correction	6,17
9.	Other	1,2,4,5,14,15,26,28,29,30,33,34, 36,37,39,42,43,47,68,69

TITLE: Corrupted data of the ends of smoothed background spectra (and hence net spectra).

Since the unsmoothed background and the gross spectra are available in the merged file of the GO tape, net spectra produced during this period can be replaced by the correct net spectra using the following procedure:

- Apply the smoothing algorithm (No. 7) to the unsmoothed background (double-pass mean filter).
- Subtract the smoothed background from the gross to produce the net.
- Note that for high dispersion data a correction must be made for the echelle blaze (see algorithm 8). The earliest version of this ripple correction was used during this period (see configuration number 6 in CSC/TM-81/6117).
- Update the scale factor record (see algorithm 12).

TITLE: Erroneous negative fluxes in extracted spectra due to incorrect integer scaling of F_{max}

In general, only a small number of points in any spectrum should be affected by this error. The affected points can be easily identified since they will appear as large negative values in a part of the spectrum where most of the fluxes are large positive values. The alternative courses of action possible are:

A. • Display the extracted files and check for large negative values as described above (an automatic program could be used to make this check). If erroneous large negative fluxes are found they should be corrected by adding 65535 ($=2^{16}-1$). If the user is limited to 16-bit signed integers, such corrected fluxes could be limited to +32767 with little error.

B. • Using the procedure above it is possible that a correct flux that was large and negative might be interpreted incorrectly. To avoid this very unlikely situation re-extract the spectrum from the photometrically corrected image (see algorithm 2).

TITLE: Unrestricted RIPPLE correction at ends of orders in high dispersion.

The ripple-corrected net spectra produced during this period had a very large correction factor applied to the end of the order (a region with little or no data) resulting in the amplification of noise (when plotted, the spectra look very messy).

- To correct this use restricted ripple correction algorithm 8.

TITLE: One-pixel error in OSCRIBE (dispersion-constant over-lay program).

The effects on assigned wavelength caused by this error are small ($\leq$ 0.7 pixel along dispersion) but variable in detail, depending on the direction in which the registration shift was applied by the processing operator. The flux error caused will be greatest for high dispersion at shorter wavelengths where the orders are close together.

- In order to correct the flux error induced by this configuration, in general the spectrum must be re-extracted from the geometrically and photometrically corrected image (see algorithm 2).
- The best approach would be for the user to start from the mean dispersion constants (see CSC/TM-81/6117, configuration numbers 56 and 57), determine any necessary registration shifts, and then use the shifted dispersion constants for the re-extraction. This method will also correct any wavelength errors.
- If the user does not have a method of determining the necessary registration shifts required by the approach given above the spectrum can be re-extracted using a modified version of the dispersion relations used for the original extraction. The original extraction was made with a set of dispersion constants defining a line parallel to the spectral order but displaced from it by one pixel in the sample direction. The change needed in the dispersion relation to make it properly overlay the spectrum could be made by incrementing the sample-direction zero-point term in the dispersion relation by +1.0 (this will move the dispersion line toward the right on a photowrite); however, since the registration shift applied by the processing operator

is unknown (e.g.; it is also possible to register the spectrum and dispersion relation by changing the line-direction zero-point term) the wavelengths derived will still be in error.

A somewhat better approach would be to modify both the line and sample zero point terms such that the required registration shift is in a direction perpendicular to the spectrum (see algorithm 6 for the information needed to do this). The wavelengths obtained in this case will probably still be incorrect but on the average the error will be less than for a sample-direction-only correction.

TITLE: Accomplish registration of spectral orders with dispersion-constant overlays by shifting the images (rather than the dispersion constants).

The geometrically and photometrically corrected image (GPI) given on the GO tape has been shifted for extraction registration (this caused errors in reseaux flagging and allowed only integer pixel shifts). In order to correct these problems the following procedure should be followed:

- Shift the GPI back to its nominal position (the amount to shift it can be determined by noting the number of rows and columns of zeroes at the image margin).
- Re-extract the data from the GPI file using suitable dispersion constants (see algorithm 2).

TITLE: Epsilon-field values in smoothed background shifted to incorrect wavelengths.

It is possible to correct for this error in both high and low dispersion by using the procedures given below.

- High dispersion. (1) Using the dispersion relations given in algorithm 4 determine the position (sample and line) of each of the reseaux flagged wavelengths in the merged file (given the wavelength assigned to a pixel, the dispersion relations will provide the sample and line position of that pixel); (2) compare the position found with all the possible positions of reseaux; (3) if there is not a reseau within seven pixels of the position found in (1) above, the wavelength was flagged erroneously and the flagging should be removed. Any flagged wavelength that does lie within seven pixels of a reseau was correctly flagged. For information on the positions of the reseaux for the SWP and LWR camera see algorithm 2.
- For low dispersion re-extract the data from the line-by-line file as per algorithm 3.

TITLE: Dispersion constant and reseau calibrations used for VILSPA reductions (1)

The effects of using the reseau-displacement file adopted by VILSPA during this period depend on the details of the particular calibration image used to generate those displacements. Although it is likely that all ill effects resulting from the displacements are small, some problems of the sort described in Configuration number 16 of CSC/TM-81/6117 may be encountered, in which case the safest and most complete procedure would be to reprocess the images in question using the mean reseau positions, for example (Configuration number 55), to define the geometric correction step.

For high dispersion images, the effects of using a given set of dispersion constants may be removed by re-extracting the spectrum from the geometrically and photometrically corrected image, using the mean dispersion relations (see Configuration number 56 of CSC/TM-81/6117).

For low dispersion images, the only significant effect of using the old dispersion constants is a possible wavelength error. The assigned wavelengths in the merged file of the GO tape can be corrected by applying the generalized correction algorithm (Algorithm 5). In this case, the primed (original) dispersion constants are those found in the processing label, and the desired (new) dispersion constants may be logically taken to be the mean relations described in Configuration number 57 of CSC/TM-81/6117).

TITLE: Error in long wavelength high dispersion wavelengths

Since the error is that the vacuum-to-air correction was applied twice, a single air-to-vacuum correction should be applied by restating the equations provided in algorithm 9. By rewriting equation (A-15),

$$\lambda_{vac} = \lambda_{air} * f\ (\lambda_{vac})$$

where the function $f(\lambda)$ is defined by equation (A-16) in algorithm 9. It is sufficiently accurate here (to within ~0.0001 Å in final answer) to evaluate the function $f(\lambda_{vac})$ as $f(\lambda_{air})$, so that

$$\lambda_{corrected}\ (\text{Å}) = \lambda_{tape}\ (\text{Å})\ *\ f(\lambda_{tape}).$$

No. 15

TITLE: Reseau flagging in low dispersion merged spectra does not distinguish between reseau mark in gross spectrum and reseau mark in background spectrum.

The line-by-line (spatially resolved) file contains the information needed to distinguish between the two types of reseau.

- Re-extract the spectrum from the line-by-line file as per algorithm 3.

TITLE: Use of non-optimal RIPPLE parameters for LWR

Since the net spectrum before ripple correction is available in the merged file of the Guest Observer tape it is possible to completely correct for this error.

- Apply the technique of algorithm 8 to the Net spectrum of the GO tape merged file using the following ripple parameters: K = 231,150 and A = 0.09.

TITLE: Extract low dispersion spectra (EXTLOW) with HT=9 and DISTANCE=8.0 (will not properly extract spectra of aperture-filling objects)

Depending on the accuracy desired the user has two options for the correction of data extracted during this period:

- Complete correction. Re-extract the data as per algorithm 2. For the extraction use the best available dispersion constants (generally the mean values - see configurations No. 56 and 57), and set HT = 15 and DISTANCE = 11.0 (see configuration No. 52 for units of DISTANCE parameter).
- Very accurate approximate solution. Extract data from the line-by-line (spatially resolved) file as per algorithm 3. Note that algorithm 3 also corrects for the error described in configuration No. 52.

TITLE: Image sequence number sometimes zeroed out in scale factor record of merged spectral file

- If the image number in bytes 13 and 14 of the scale factor record (the first record of the merged file) is zero read the correct number from bytes 53-56 of the first line of the raw image file (see Turnrose, B.E., and Harvel, C.A., 1980 for information on formats for image labels and the scale factor record).

TITLE: Use of incorrect offsets from small to large aperture in LWR.

Since the vector between the incorrect and the correct offset positions lies chiefly along the high dispersion orders (it is therefore almost perpendicular to the low dispersion order) this is primarily a high dispersion problem. The only errors are wavelength errors.

- High dispersion. Red shift all high dispersion wavelengths by 48.6 km/sec; that is,

$$\lambda_{correct} = (1.000162)\ \lambda_{incorrect}$$

- Low dispersion. The errors involved are not significant (~ 1 Å).

- Alternatively, the formalism of algorithm 6 may be used to derive the precise parallel and perpendicular components of the difference between the correct and the incorrect small-to-large aperture offsets in either dispersion mode. From CSC/TM-81/6117 (configuration 21) it is seen that the line and sample components of the difference between the offsets to be entered in algorithm 6 are:

$$\Delta L = 19.5 - 25.1 = -5.6$$
$$\Delta S = -17.5 + 21.1 = 3.6$$

The parallel component $\Delta\|$ from algorithm 6 is then related directly to the wavelength or velocity error incurred.

TITLE: Error in SWP low dispersion wavelength scale

The wavelength in the merged file of the GO tape can be corrected by one of the two alternative methods below. The first is a general method (see also configuration No. 24) and the second has been empirically derived by VILSPA specifically for this error.

A. • Obtain the incorrect dispersion constants used for the extraction from the processing label and use these and a set of good dispersion constants (the means would be the best--see configuration number 57) as input to the low dispersion wavelength correction algorithm (algorithm 5).

B. • Correct the wavelengths λ_{tape} obtained from the GO tape by the VILSPA formula:

$$\lambda_{corrected}\ (A^{o}) = (1.0158 \pm 0.0002) * \lambda_{tape}\ (\text{Å}) - 20.00$$

Note that the correction formula published in ESA IUE Newsletter No. 3, p. 6, has an incorrect sign for the -20.00 term.

TITLE: Camera number transmitted as true number plus 10 or 20 in scale factor record of merged spectral file.

For images extracted during this period use the following procedure.

- Read camera number from scale factor record (see Turnrose, B.E., and Harvel, C.A., 1980 for information on image labels and scale factor record) and set it equal to CAM. Then use this FORTRAN procedure:

```
 99 IF (CAM.LE.4)  GO TO 100
    CAM = CAM -10
    GO TO 99
100 CONTINUE
```

When this section of code is completed the value of CAM will be the correct camera number.

No. 24

TITLE: Determine SWP low dispersion wavelength calibrations from preliminary version of line library.

The wavelengths in the merged file of the GO tape can be corrected by the following procedure:

- Obtain the incorrect dispersion constants used for the extraction from the processing label and use these and a set of good dispersion constants (the means would be the best - see configurations No. 56 and 57) as input to the low dispersion wavelength correction algorithm (algorithm 5).

TITLE: Extract low dispersion large-aperture point-source spectra with DISTANCE = 8.0

Depending on the accuracy desired the user has two options for correction of data extracted during this period:

- Complete correction. Re-extract the data as per algorithm 2. For the extraction use the best available dispersion constants (generally the means--see configurations No. 56 and 57) and set DISTANCE = 11.0 (see configuration No. 52 for units of DISTANCE parameter).
- Very accurate approximate solution. Extract data from the line-by-line (spatially resolved) file as per algorithm 3. Note that algorithm 3 also corrects for the error described in configuration No. 52.

No. 28

TITLE: Omit vacuum-to-air correction for LWR low-dispersion single-aperture reduction.

To correct data reduced during this period proceed as follows:

- Check the wavelengths in the extracted spectrum for a 0.65 Å discontinuity at 2000 Å; if such a discontinuity is found the data do not need to be corrected.
- If the discontinuity is not there correct the data as per algorithm 9.

TITLE: Dispersion constant and reseau calibrations used for VILSPA reductions (2).

Same as configuration No. 14.1.

TITLE: Dispersion constant and reseau calibrations used for VILSPA reductions (3).

Same as configuration No. 14.1, with the exception of the discussion of high dispersion re-extraction, which is not relevant to low dispersion.

TITLE: Improperly convert certain spectral files with negative fluxes to GO-tape integer format

This problem principally affects background spectra extracted from images with low null levels (see CSC/TM-81/6117). In such cases, as long as the gross and net spectra are not also affected, a new smoothed background can be obtained by subtracting the net spectrum from the gross spectrum. If the gross and/or net spectra are also affected, or if the unsmoothed background is required, then re-extraction from the photometrically corrected image is necessary. The alternative courses of action are thus:

A.
- Display gross and net spectra from merged file and verify that fluxes behave as expected--i.e., that these spectra are not affected by this problem.
- Subtract net spectrum from the gross spectrum, point-by-point, to obtain the smoothed background spectrum.

B.
- Re-extract spectra from the photometrically corrected image (see algorithm 2).

No. 44

TITLE: Use of SWP ITF with incorrect 20% exposure level

The problem is addressed in two ways, depending on the dispersion mode of the images affected. Whereas for low dispersion, suitable correction techniques have been published and used successfully, for high dispersion a complete reprocessing is required.

A. Low Dispersion

- Apply the correction algorithm SWPFIX (Cassatella et al, 1980) or an alternative (Holm and Schiffer, 1980). These methods work on the extracted spectra (line-by-line or merged).

B. High Dispersion

- Reprocess the image from its raw form (see algorithm 1)

TITLE: Use of non-optimal pixel offsets from small to large aperture

The most important effect of using pixel offsets to the large aperture which do not correspond exactly to the point at which objects were normally placed in the aperture is that the assigned wavelengths will be slightly in error, as described in CSC/TM-81/6117. Any component of misplacement perpendicular to the dispersion direction would have already been compensated in the registration procedure done prior to the spectral extraction. The steps to be taken to correct the error are as follows:

A.

- In low dispersion,

$$\lambda_{correct} = \lambda_{old} + \Delta\lambda$$

where $\Delta\lambda = \begin{cases} -0.23\text{Å} & \text{in SWP} \\ +1.76\text{Å} & \text{in LWR} \end{cases}$

- In high dispersion,

$$\text{velocity}_{correct} = \text{velocity}_{old} + \Delta v$$

where $\Delta v = \begin{cases} -0.13 \text{ km s}^{-1} & \text{in SWP} \\ -11.8 \text{ km s}^{-1} & \text{in LWR} \end{cases}$

Here, velocity is the radial velocity assigned to a spectral feature based on a comparison of its observed wavelength to its rest wavelength, in km s^{-1}. The use of velocity, rather than wavelength, is convenient in high dispersion where a constant-pixel offset corresponds to a constant-velocity offset (rather than a constant-wavelength offset as in low dispersion).

Wavelength offsets are related to velocity offsets by

$$\Delta\lambda = \frac{\lambda \ \Delta v}{C}$$

where C = speed of light = 3×10^5 km s^{-1}. The offset values presented here are taken from "IUE Data Reduction V."

B.

- Alternatively, the formalism of algorithm 6 may be used to derive from scratch the parallel and perpendicular components of the difference between the correct and the incorrect small-to-large aperture offsets. The parallel component is then converted to wavelengths or velocities as further described in algorithm 6, yielding the same offset values as were presented in method A above.

TITLE: Use biweekly dispersion-constant calibrations in low dispersion

As is the case for configuration number 45, the most important effects in this situation are those relating to the assignment of wavelengths, since the effects of differing dispersion relations are already removed by the spectral registration step in the direction perpendicular to the dispersion. To change the low dispersion wavelengths to those corresponding to the mean dispersion relations, proceed in the following way:

- Apply the wavelength correction as described in algorithm 5, where the original dispersion relations are those used to do the spectral extraction and written in the IUESIPS image label (with registration shifts included), and the new dispersion relations are the mean values listed in CSC/TM-81/6117 under this configuration number. Note that for large-aperture data, the appropriate zero-point offsets to the large aperture (see CSC/TM-81/6117 configurations number 45 and 46) should be added to the mean values.

No. 50

TITLE: Do not provide absolutely calibrated net spectrum in low dispersion

- Use algorithm 10 to apply absolute calibration to net spectrum. Note that on IUE output tapes, all extracted spectra are in time-integrated form, including the ABNET spectra provided after IUESIPS configuration number 50.

TITLE: Incorrect units for DISTANCE parameter in EXTLOW

Inasmuch as the line-by-line spectra produced by EXTLOW were unaffected by this problem (which pertained to the merged file of slit-integrated spectra), an adequate correction may be obtained by utilizing the line-by-line data. Thus two alternative methods of correction may be used:

A.
- Use line-by-line file ESSR (see Turnrose and Harvel, 1980) to emulate merged spectral data with background sampled at proper distance from dispersion line (see algorithm 3).

B.
- Re-extract background spectrum from photometrically corrected image at proper distance from order to redefine a corrected merged spectral file (see algorithm 2).

No. 53

<u>TITLE</u>: Use original <u>Astron. Astrophysics</u> absolute calibration

- Use algorithm 10 to apply improved absolute calibration to net spectrum. Note that on IUE output tapes, all extracted spectra are in time-integrated form, including the ABNET spectra provided by IUESIPS.

TITLE: Use preliminary mean dispersion constants for low dispersion

Since the refined mean dispersion constants differed from the preliminary constants chiefly in the zero-point term, a reasonable correction to the extracted wavelengths may be obtained by considering the parallel component of the zero-point shift above. Alternatively, the small variation in scale may be considered explicitly. Note that in either case, only the effects of the changed dispersion relations on wavelength are relevant, since effects in the direction perpendicular to the dispersion would have already been removed by the spectral registration procedure.

A. ● Ignoring the small difference in scale terms (A_2 and B_2) between the preliminary and refined dispersion constants, define ΔL and ΔS offsets as

$$\Delta L = B_1' - B_1$$

$$\Delta S = A_1' - A_1$$

where the primed quantities are the new zero-point terms (see CSC/TM-81/6117), and the unprimed quantities are the zero-point terms actually used in the extraction process (obtained from IUESIPS label). Use algorithm 6 to calculate the corresponding $\Delta||$ and wavelength correction. Note that for large-aperture data, the appropriate small-to-large aperture offsets must be added to the new means used.

B. ● Apply the full wavelength correction procedure in algorithm 5. Here, the new dispersion constants are the new mean values (with offset to large aperture added, if applicable) and the old dispersion constants are the actual values taken from the IUESIPS label, including registration shifts.

TITLE: Inaccurate automatic registration programs

Two types of correction may be made for this problem, corresponding to the two types of error introduced. A wavelength error caused by the slight non-perpendicularity of the applied registration shifts is correctable by an algorithm, whereas a flux error caused by the overall shift-magnitude error requires re-extraction.

A.
- If the registration shift values are available from the IUESIPS label, correct the applied shifts by the amounts and in the sense shown in the discussion of configuration 58 in CSC/TM-81/6117.
- Then define ΔL and ΔS as the differences between the corrected and uncorrected line and sample shifts, respectively, and use algorithm 6 to calculate the corresponding $\Delta ||$ and wavelength or velocity correction. This method provides no flux corrections.

B.
- If the registration shifts are not written in the IUESIPS label, in low dispersion a reasonable alternative is to correct the assigned wavelengths with algorithm 5, using the mean dispersion constants as the "new" constants and the actual dispersion constants in the label (which include the unknown shifts) as the "original" constants. In high dispersion such an alternative is not defined.

C.
- Provided that corrected dispersion relations are available (see A above), re-extract the spectrum from the photometrically corrected image (see algorithm 2). This method corrects both the wavelengths and the extracted fluxes.

TITLE: Incorrectly transmit 5-digit image sequence numbers to scale-factor record of extracted spectral files.

Inasmuch as the problem for the affected SWP images is simply that the image number in binary integer format in bytes 13-14 of the scale-factor record (first record after IUESIPS label) is too small by 10,000, complete correction may be obtained by decoding the halfword integer, adding 10,000, and recoding the result to binary halfword integer form and storing in the scale-factor record.

TITLE: Processing of low dispersion spectra using the programs GEOM, FICOR, and EXTLOW

In general, the benefits and file formats of the new low dispersion data processing software which replaced the programs named above are attainable either exclusively or most conveniently by complete reprocessing (algorithm 1). One aspect of the new software, however, the increased sampling frequency and number of extracted points per order, may be emulated algorithmically as follows, although this technique has not actually been tried on IUE data.

- Interpolate the existing spectral samples with a suitable interpolation function such as the sinc function described by Lorre (1978). Applying Lorre's method to the one-dimensional case at hand, obtain

$$I(X) = \sum_{i=X-\Delta}^{X+\Delta} I(i) \frac{\sin(X-i)\pi}{(X-i)\pi}$$

where $I(x)$ is the interpolated intensity at intermediate wavelength location X, $I(i)$ is the sampled intensity at the ith wavelength, and Δ is the half-width of the interpolation filter. Note that the values of i at the summation limits are rounded to integer values. The sampling frequency of the new software may be emulated by choosing an X midway between every i (that is, nominal sampling interval $\sqrt{2}/2$ pixels instead of $\sqrt{2}$). Note that this is only an approximate procedure because the original sampling interval is not uniform. The user is referred to Pratt (1978) for further details and considerations relating to this and other possible interpolation techniques, including the choice of Δ.

No. 61

TITLE: Non-perpendicular manual shifts (REGISTER)

The correction for non-perpendicularity of shifts here cannot be treated as exactly as in configuration number 58 since the applied shifts are manually determined and hence not exactly reproducible. However, straightforward procedures may be defined to correct wavelengths for the error which might have been introduced in the shifting process.

A.

- If the registration shifts ΔL and ΔS are available from the IUESIPS label, use algorithm 6 to calculate the corresponding parallel and perpendicular shifts, $\Delta ||$ and $\Delta \perp$. If $\Delta ||$ is non-zero, use it to compute the corresponding wavelength or velocity correction as in algorithm 6. All $\Delta ||$ is zero, no correction is necessary.

B.

- If the registration shifts are not written in the IUESIPS label, just as in configuration number 58 a reasonable alternative in low dispersion is to correct the assigned wavelengths with algorithm 5 using the mean and the original dispersion constants. In high dispersion a similar alternative is not defined.

No. 63

TITLE: Incorrect manual shift for SWP images (REG).

The correction for non-perpendicularity of shifts is the same as that discussed for configuration number 61.

TITLE: VBBLK without label processing

- Change the starting line (SL) and starting sample (SS) values in first record of IUESIPS image label from 0895 to 0001. See Turnrose and Harvel (1980) for label format details.

No. 65

TITLE: Incorrect entries in label by SPECLO (negative declination and zero shift)

- For objects with negative declination, change sign of declination in the line of IUESIPS image label which reads "TARGET COORD. (1950):" . Declination should be correct already in line 37 of label (see Turnrose and Harvel, 1980, p. 8-15).
- For images in which the IUESIPS label reads "LINE SHIFT=YY.YYY SAMPLE SHIFT=XX.XXX", change YY.YYY and XX.XXX to 0.0

TITLE: Calibration files without temperature corrections (low dispersion)

In order to correct for the thermal motion of reseau marks, it is necessary to reprocess the image from its raw form (see algorithm 1). The correction of wavelengths for thermal and temporal spectral format motion, however, may be accomplished algorithmically or by re-extraction (algorithm 2). The algorithmic correction procedure is described below.

- Read the day and year (IDAY and IYR) of approximate image READ from the image label as discussed in algorithm 14, and calculate the elapsed GMT day number since 31 December 1977 (ignoring leap years) as

  LGMT = IDAY + (IYR-78) * 365.

  An alternative approach is to calculate this day number from data on the handwritten observing script.

- Read the camera head amplifier temperature (THDA) at the end of the exposure from the image label using algorithm 14, if the image was acquired after March 1979. An alternative source of the THDA is the hand-written observing script.

- Use the dispersion constants given in the IUESIPS image label to calculate the line and sample positions (L,S) corresponding to the arbitrary fiducial wave-length 1500 Å in SWP or 2600 Å in LWR. (see algorithm 4).

- Refer to Figure 2-1 for SWP and Figure 2-2 for LWR. These figures show the loci of pixel addresses, in the line and sample number plane, of the fiducial wave-lengths 1500 Å (SWP) and 2600 Å (LWR), in the small aperture, as functions of both time and THDA. The trajectories for constant time and constant temperature were constructed on the basis of the time and temperature correlation studies used to correct for spectral format motion in current production processing (see "IUE Data Reduction XXI"). By interpolating between the two types of loci drawn in the figures, the user may determine the predicted small-aperture line and sample coordinates (L_o, S_o) of the fiducial wavelengths at any relevant given time and temperature. Whereas these coordinates represent the best-guess temperature/time corrected positions, the coordinates (L,S) calculated above from the dispersion relations in the image label represent the uncorrected positions used in the wavelength assignment process during the spectral extraction. The difference between these positions can thus be used as shown below to infer and correct possible wavelength errors in the extracted spectrum.

- If spectra in question are in the large aperture, add the appropriate line and sample offsets to the (L_o, S_o) values interpolated from Figure 2-1 or 2-2 (see CSC/TM-81/6117, configurations number 45 and 46) to obtain (Lc, Sc).
- Define $\Delta L = L_c - L$
  $\Delta S = S_c - S$
- Use algorithm 6 to calculate the parallel shift $\Delta||$ and the resulting wavelength correction corresponding to ΔL and ΔS. This effectively reduces the wavelength scale to the temperature/time corrected system.

No. 71

TITLE: Dispersion constant and reseau calibrations used for VILSPA reductions (4).

Same as configuration No. 14.1.

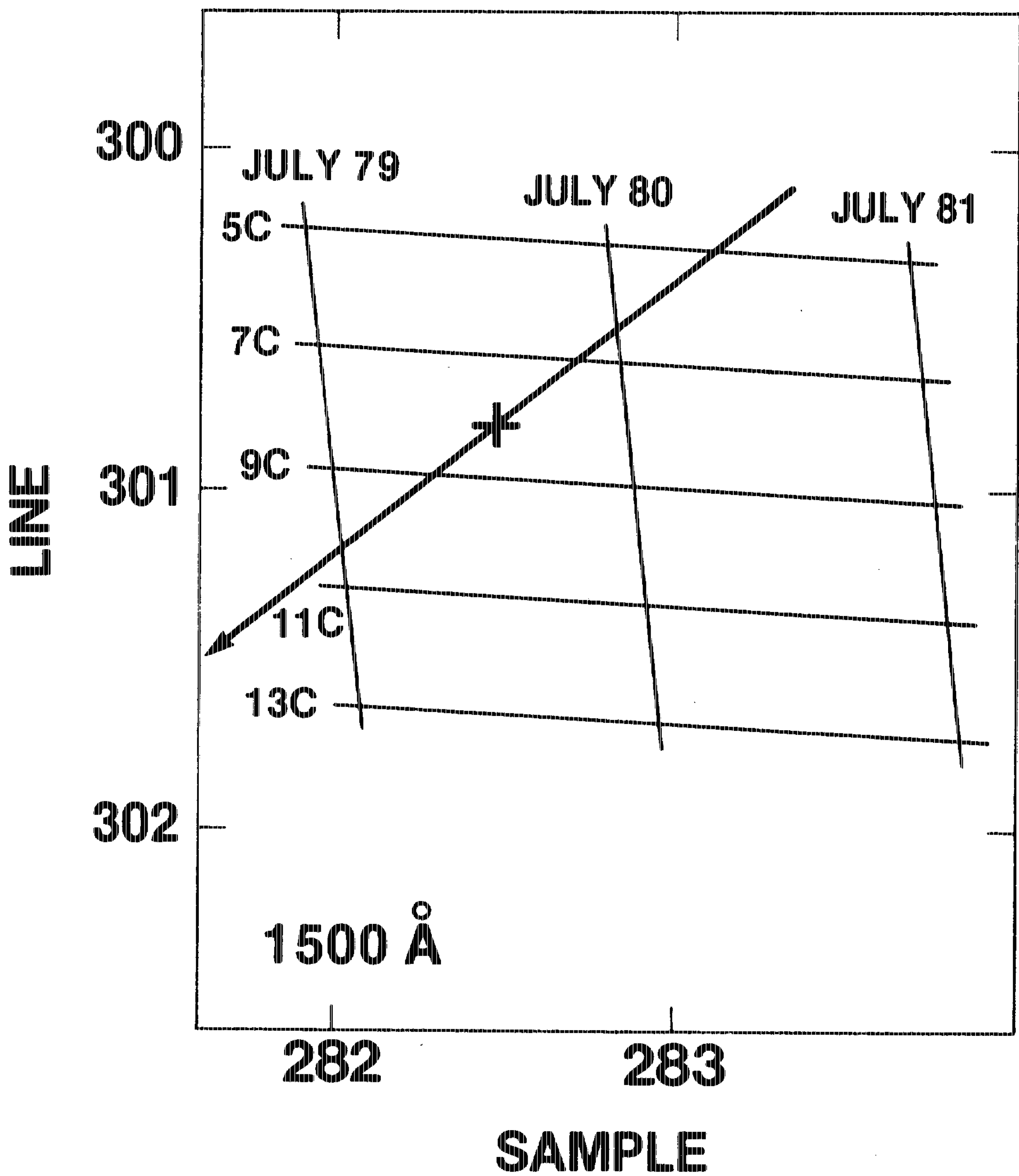


Figure 2-1 Loci of predicted trajectories of λ = 1500 Å point, small aperture, for various times (month and year marked) and THDA (degrees Celsius marked) in SWP low dispersion. Shown as a "+" is the position corresponding to the current mean dispersion relations; the direction of dispersion is also plotted as a vector passing through the mean point. Prepared by R.W. Thompson.

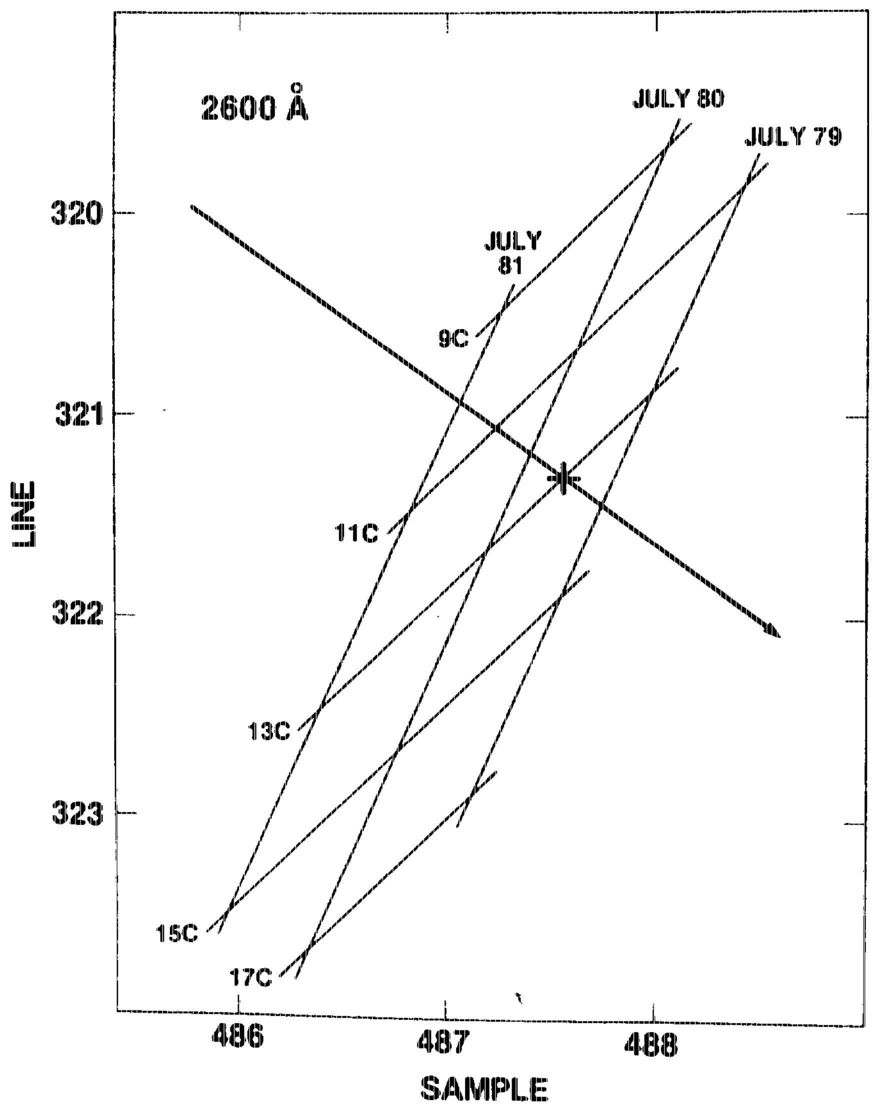


Figure 2-2 Loci of predicted trajectories of λ = 2600 Å point, small aperture, for various times (month and year marked) and THDA (degrees Celsius marked) in LWR low dispersion. Shown as a "+" is the position corresponding to the current mean dispersion relations; the direction of dispersion is also plotted as a vector passing through the mean point. Prepared by R.W. Thompson.

APPENDIX A

GENERAL - PURPOSE METHODS

Algorithm 1 - Complete reprocessing:

The requirements associated with the complete reprocessing of an IUE image are extensive. In this context, the reprocessing of an image is defined to be the sum of all calculational steps necessary to produce an extracted spectrum, starting from the raw 768 x 768 image. The many separate steps which constitute the processing, from dealing with the geometric distortion, correcting for the camera non-linearities and non-uniformities (photometric correction), applying dispersion relations, extracting spectral data, and finally, manipulating the extracted spectral data, have been described in several references (Perry and Turnrose, 1977; Klinglesmith, Perry, and Turnrose, 1979; Lindler, 1979a,b; Turnrose and Harvel, 1980). In addition, refinements and modifications to the processing procedures are addressed in many articles of the series IUE Data Reduction I-XX published in the NASA IUE Newsletter, Nos. 2-13 (see Appendix B).

From a computational standpoint, the steps placing the greatest demand on the processing system are those which handle the geometric distortion (either explicitly or implicitly; see IUE Data Reduction VI and XVIII), the photometric correction using the Intensity Transfer Function (ITF), and the actual spectral extraction from the photometrically-corrected image. These steps all involve the use of large, two-dimensional arrays (the image and ITF data) and in practice are designed so as to work with only several lines of an image at a time (Perry and Turnrose, 1977; Lindler, 1979a,b.). This is necessary since raw images contain 589,824 bytes, the ITF files contain 6,488,064 bytes (SWP) or 7,077,888 bytes (LWR), and photometrically corrected images contain 1,179,648 bytes.

The format and the use of these files are discussed in Perry and Turnrose (1977), and Turnrose and Harvel (1980). These references also contain explicit equations describing the geometric and photometric correction algorithms always used for high dispersion (see also IUE Data Reduction XIII for the ITF extrapolation techniques now incorporated), and Lindler (1979a,b) and IUE Data Reduction XVIII provide specific algorithms and discussion pertaining to the new implicit-geometric-correction software used for low dispersion since 3 November 1980 at GSFC and since 10 March 1981 at VILSPA.

Specific considerations relating to the extraction of spectral data from the photometrically corrected images and the subsequent manipulation of the extracted spectra are addressed in other general purpose algorithms in this Appendix.

Algorithm 2 - Spectral extraction from photometrically corrected image:

The ability to extract spectral data from a photometrically corrected image, while less of a computational burden than full reprocessing, places considerable demands on processing systems. The need to handle large amounts of data (1,179,648 bytes per photometrically corrected image), the need to extract data from orders positioned neither horizontally, vertically, nor along the diagonal, and the need to flag exceptional pixels (reseau-contaminated pixels, saturated pixels, extrapolated pixels) are significant factors. Many aspects of the extraction problem are addressed in detail in Turnrose and Harvel (1980) for the "old" software which extracts spectral data from photometrically and geometrically corrected images and in Lindler (1979a,b) for the "new" software which extracts spectral data from photometrically corrected images with raw geometry.

The use of analytic dispersion relations to define the locus of points in the image representing the nominal position of the spectral orders is discussed in Turnrose and Harvel (1980) and under a separate algorithm in this Appendix. The procedures for registering the nominal dispersion relations with the actual spectral orders are also discussed in Turnrose and Harvel (1980). The sampling algorithms for actually extracting spectral flux values are discussed in the above reference and in Lindler (1979a,b). The flagging mechanism by which extracted flux points affected by exceptional pixels are identified is discussed partially in several references and elaborated upon below.

Reseau flagging. As described in IUE Data Reduction XVII, the geometrically correct reseau grid (i.e., the reseau locations to which the geometric correction step -- either explicit or implicit -- maps the found reseau positions) for each camera consists of a 13 x 13 array of reseau marks laid out in a square pattern extending across and beyond the tube face. In every case, the "central" reseau mark - that lying in row 7, column 7 of the grid -- is positioned at line number 390, sample number 410 in the geometrically corrected frame of reference. In the LWP and LWR cameras, the spacing between adjacent reseau marks is 55 pixels in both the line and sample directions, implying that the reseau mark in row 1, column 1 of the grid is situated at line number 60, sample number 80. In the SWP camera, the spacing between adjacent reseau marks is 56 pixels in both the line and sample directions, implying that the reseau mark in row 1, column 1 of the grid is situated at line number 54, sample number 74. For the SWR camera, not used for Guest Observer science data, a suitable reseau grid has not been defined.

As flux values are sampled in the extraction process, (under either the "old" or the "new" software), reseau marks which are calculated to lie within 2 pixels of any pixel contributing to the measured flux are flagged by negative values of the quality-measure ε. (See the discussion of configuration number 15 in CSC/TM-81/6117). Note that the description on p. 6-9 of Turnrose and Harvel (1980) is incorrect in stating that only reseau within 2 pixels of the center of an extraction slit are flagged.

Exceptional-flux-condition flagging. In the "old" (explicit geometric correction) software, only saturated pixels (DN = 255) are flagged in extracted spectra (see Turnrose and Harvel, 1980). In the "new" (implicit geometric correction) software a considerably more extensive flagging system for exceptional flux conditions is built into the coding of pixel values in the photometrically corrected image itself (see IUE Data Reduction XVIII and CSC/TM-81/6117, configuration number 60).

This more extensive system allows for the flagging of saturated pixels and pixels whose fluxes are based on ITF extrapolations and in the future will also flag pixels affected by bright spots (radiation artifacts) and camera microphonic noise patterns.

Following the actual extraction of spectral data, including the conditional flagging discussed above, the gross and background fluxes are further manipulated (Turnrose and Harvel, 1980; IUE Data Reduction XVIII) to define net spectra which in low dispersion are also absolutely calibrated. The important aspects of the various manipulations done to the extracted spectra are individually discussed in the other general-purpose algorithms in this Appendix, as they have considerable application to many of the specific correction procedures addressed in the main text of this document.

Algorithm 3 - Psuedo-slit extractions from line-by-line spectra

In low dispersion, a line-by-line or spatially resolved spectrum is provided from which pseudo-slit extractions can be made on even small computers to correct, improve upon, or otherwise customize the equivalent of the IUE merged-spectral file. This is particularly convenient since the data are presented in relatively small arrays and since wavelengths and quality flags (ε) are already assigned to each flux point. With the "old" low dispersion software, the line-by-line spectra consist of 55 gross pseudo-orders extracted parallel to the direction of the dispersion with a square sampling area $\sqrt{2}$ pixels by $\sqrt{2}$ pixels oriented at an angle of 45 degrees to the line and sample directions. As Cassatella et al (1980) point out, each such line-by-line flux sample includes portions of between 4 and 7 pixels of the geometrically and photometrically corrected image. The line-by-line spectra are arranged as 55 pseudoorders which collectively extend completely across and between both spectrograph apertures and where the 28th line is nominally centered on the dispersion line and assigned an "order" number of 100. In all, "order" numbers 73 to 127 are assigned to the line-by-line extractions, with the order numbers increasing as one progresses from the large aperture towards the small aperture in each camera. The detailed format of the data on tape is discussed in Turnrose and Harvel (1980).

With the "new" low dispersion software, (IUE Data Reduction XVIII and XIX) the line-by-line spectra are extracted by a different technique but provide similarly-organized data, with a greater number of sampled flux points per order.

As indicated in Cassatella et al. (1980), the gross and background extractions performed by IUESIPS in calculating the standard merged spectral files may be emulated by summing flux points at constant wavelength from the appropriate corresponding lines of the line-by-line file. Table A-1 summarizes the range of lines to be summed for each of the several aperture/source-characteristic options in use currently. The Guest Observer or archive user may also wish

Table A-1. Range of line numbers to be summed in spatially-resolved file to emulate merged spectra.

	Small Aperture	Large Aperture	
		Point Source	Extended/Trailed Source
Gross	24 - 32	24 - 32	21 - 35
Background	18-22 plus 34-38	15-19 plus 37-41	15-19 plus 37-41

to define different "swaths" through the line-by-line array to optimize the flux measurements for a particular application: very faint point sources, for example, could be more profitably sampled with a shorter gross "slit" (i.e., fewer lines added together) to reduce the effects of extraneous noise from the underlying background.

Note that in all cases of pseudo-slit extraction, the effective pixel areas of the background and gross "slits" must be normalized before a net signal can be defined.

Algorithm 4 - Wavelength assignments via dispersion constants:

The relation between wavelength and nominal pixel location in IUE images is determined by analytical dispersion relations, as described in Turnrose and Harvel (1980). The analytical dispersion relations utilize a set of dispersion constants A_i and B_i which are determined by a multivariate regression analysis. The relations, which separately determine the line and sample numbers corresponding to a given wavelength λ (in Å) and echelle order number m, are the following:

$$\text{sample number} = A_1 Z_1 + A_2 Z_2 + A_3 Z_3 + \ldots\ldots + A_7 Z_7 \qquad \text{(A-1)}$$

$$\text{line number} = B_1 Z_1 + B_2 Z_2 + B_3 Z_3 + \ldots\ldots + B_7 Z_7 \qquad \text{(A-2)}$$

where

$$\begin{aligned} Z_1 &= 1 \\ Z_2 &= m\lambda \\ Z_3 &= (m\lambda)^2 \\ Z_4 &= m \\ Z_5 &= \lambda \\ Z_6 &= m^2\lambda \\ Z_7 &= m\lambda^2 \end{aligned} \qquad \text{(A-3)}$$

In the case of low dispersion, only the first two terms in equations (A-1) and (A-2) are used, and $m \equiv 1$.

A method of inverting dispersion relations of the form of equations (A-1) through (A-3) so as to, for example, solve for the sample and wavelength values at which a given order m crosses a particular line in the image is described on pages 4-31 and 4-32 of Perry and Turnrose (1977).

The values of the A_i and the B_i used to extract the spectral data of an IUE image are recorded in the IUESIPS history portion of the label (see Turnrose and Harvel, 1980, pages 8-19, 8-20) and for the "new" low dispersion software, also in the scale-factor record of the extracted data (IUE Data Reduction XVIII). Consequently, the Guest Observer or archive user wishing to use the standard dispersion formulae to assign wavelength values to image pixels (in the geometrically correct frame of reference) may utilize the A_i and B_i values and the methods described herein. Users are cautioned that in the case of images reduced under the "new" implicit-geometric-correction software, the pixel locations associated with the dispersion formulae must be referred back to the raw-image geometry according to the algorithm presented on p. 22 of Lindler (1979b). Mean values for the displacement data sets needed for Lindler's algorithm can be obtained from IUE Data Reduction XVII; the variation of instanteous displacements from these means due to thermal effects will in general be small (IUE Data Reduction XXI).

Algorithm 5 - Low dispersion wavelength corrections:

In "IUE Data Reduction III" in NASA IUE Newsletter, No. 5, a correction algorithm for low dispersion wavelengths is derived. This algorithm, while derived for the purpose of correcting SWP low dispersion wavelengths for the effects of the preliminary SWP low dispersion line library (see CSC/TM-81/6117, configuration number 24), is generally applicable to any low dispersion situation in which wavelengths generated from a given set of dispersion constants need to be transformed to the corresponding wavelengths that would be generated from a second set of dispersion constants. This algorithm would, therefore, be useful to users who wish, for example, to convert wavelengths assigned with biweekly dispersion constants to wavelengths assigned with mean dispersion constants.

Given that the original dispersion relations are

$$\text{sample number} = a_1' + a_2' \lambda_o \qquad \text{(A - 4)}$$

$$\text{line number} = b_1' + b_2' \lambda_o \qquad \text{(A - 5)}$$

and the desired (new) dispersion relations are

$$\text{sample number} = a_1 + a_2 \lambda \qquad \text{(A - 6)}$$

$$\text{line number} = b_1 + b_2 \lambda \qquad \text{(A - 7)}$$

then the relation between the original wavelength λ_o and the converted wavelength λ is

$$\lambda = d + m \lambda_o \qquad \text{(A - 8)}$$

where

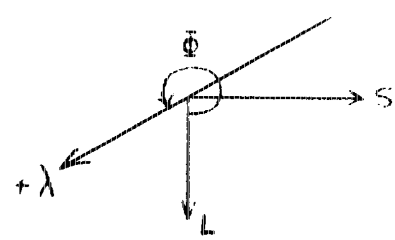
$$d = \frac{b_2 (b_1 - b_1) + a_2 (a_1' - a_1)}{b_2^2 + a_2^2} \qquad \text{(A - 9)}$$

$$m = \frac{b_2 b_2' + a_2 a_2'}{b_2^2 + a_2^2} \qquad \text{(A - 10)}$$

Algorithm 6 - Wavelength corrections for zero-point shifts:

For many applications it is useful to have a method by which assigned wavelengths can be transformed approximately, given a simple zero-point shift in the dispersion relations. Such a situation corresponds to deriving the effect of changing the A_1 and B_1 terms in equation (A-1) and (A-2) discussed in algorithm 4. The uses of such a method include estimating the effects of thermal shifts and non-perpendicular registration shifts, for example. The method shown below was developed by R. W. Thompson as part of the analysis of thermal shifts in IUE images in the SWP and LWR cameras and consists of decomposing line and sample direction shifts, ΔL and ΔS, into equivalent components parallel and perpendicular to the dispersion direction, $\Delta \|$ and $\Delta \perp$. In this formulation, $\Delta \|$ and $\Delta \perp$ are defined in a right-handed coordinate system such that positive $\Delta \|$ (the " + X axis") is in the direction of increasing wavelength.

First, we note that it is possible to define with little uncertainty an angle Φ which is the angle of the dispersion direction with respect to the direction of positive line number, thus:



In low dispersion, Φ is unique for each camera; in high dispersion, Φ varies slightly with order number (total variation ~ $0\overset{\circ}{.}7$ between orders 125 and 75). The whole-number values of Φ adopted here in Table A-2 are thus correct for all orders to within ~ $0\overset{\circ}{.}5$.

Table A-2 Dispersion-line angles (rounded to nearest degree)

Camera	Dispersion	Φ (in radians)
SWP	Low	$309 \times \frac{2\pi}{360}$
	High	$38 \times \frac{2\pi}{360}$
LWR	Low	$53 \times \frac{2\pi}{360}$
	High	$324 \times \frac{2\pi}{360}$

For a given line shift ΔL and sample shift ΔS, define

$$R = (\Delta L^2 + \Delta S^2)^{1/2} \qquad (A - 11)$$

If $\Delta L > 0.0$ and $\Delta S \geq 0.0$, $\theta = \arctan\left(\frac{\Delta S}{\Delta L}\right)$

If $\Delta L \leq 0.0$ and $\Delta S > 0.0$, $\theta = \left|\arctan\left(\frac{\Delta L}{\Delta S}\right)\right| + \pi/2$

If $\Delta L < 0.0$ and $\Delta S \leq 0.0$, $\theta = \arctan\left(\frac{\Delta S}{\Delta L}\right) + \pi$

If $\Delta L \geq 0.0$ and $\Delta S < 0.0$, $\theta = \left|\arctan\left(\frac{\Delta L}{\Delta S}\right)\right| + \frac{3\pi}{2}$

Then

$$\Delta_{||} = R \cos (\theta - \Phi) \qquad (A - 12)$$

$$\Delta_{\perp} = R \sin (\theta - \Phi) \qquad (A - 13)$$

If $\Delta L = 0 = \Delta S$, $\Delta_{||} = 0 = \Delta_{\perp}$.

The interpretation of $\Delta\|$, which is the only component of the shift pertinent to the wavelength scale, depends on the dispersion mode. In low dispersion, a motion of one pixel along the dispersion direction corresponds to a shift of 1.67 Å in SWP and 2.65 Å in LWR (see "IUE Data Reduction V"). In high dispersion, a motion of one pixel along the dispersion direction corresponds closely to a constant velocity (not wavelength) shift of 7.64 km s^{-1} in SWP and 7.32 km s^{-1} in LWR (see "IUE Data Reduction XXI").

Note that in relating a calculated $\Delta\|$ to a wavelength or a velocity shift, it is important to keep in mind whether motion of the object spectrum or of the dispersion relations is being addressed. A change in the A_1 and B_1 values in equations (A-1) and (A-2), for example, so as to move the dispersion relation zero-point in the positive wavelength (velocity) direction will result in assigned spectral wavelengths (velocities) which are smaller by the amount of the shift.

Algorithm 7 - Background smoothing:

IUE low dispersion background spectral fluxes are currently smoothed with a median filter, followed by a double-pass mean filter. A median filter replaces the central point within the filter "window" (the set of neighboring points falling within the filter width) by the median of the samples within the window; a mean filter replaces the central point of the window by the mean of the points within the window. (See "IUE Data Reduction X"). Under the former low dispersion software (pre-November 3, 1980 at GSFC and pre-March 10, 1981 at VILSPA), only the double-pass mean filter was used. Although the current (old) high dispersion software at GSFC uses the old-style double mean-only filtering, the median-plus-double-mean filter is used at VILSPA and will be part of the new high dispersion reduction system; it is therefore the recommended method.

A suitable median-filter algorithm is presented in Schiffer and Holm (1980). With the "new" extraction software with $\frac{\sqrt{2}}{2}$ spacing between adjacent spectral samples, a median filter width W_{median} of 63 points should be used; the mean filter width W_{mean} is 31 points. With the "old" extraction software with $\sqrt{2}$ spacing between adjacent spectral samples, $W_{median} = 31$ and $W_{mean} = 15$ should be used. As noted in Cassatella et al. (1980), filtering algorithms are preferred in which the effective filter window collapses in width once the filter is within W/2 points of the end of the data string. By keeping only valid data points within the filter windows, unwanted artifacts in the smoothed data are avoided.

Algorithm 8 - Ripple correction:

In high dispersion, the net spectrum is corrected for the echelle grating blaze function (the "ripple") with a simplified, semi-empirical formula. More suitable formulae may exist; recent studies suggest that the effective grating constants K (see below) may vary with order number (Ake, 1981; Benvenuti, 1981). This effective variability of K may in fact be due to other causes as yet not fully understood.

The extracted net spectrum $F(\lambda)$ is obtained from the fifth record of each 6-record data group for each order (Turnrose and Harvel, 1980, p. 8-41) and rescaled to floating point format (see algorithm number 10). The ripple-corrected net spectrum $F_{corr}(\lambda)$ is obtained as follows:

$$F_{corr}(\lambda) = \frac{F(\lambda)}{R(\lambda)} \qquad \text{(A - 14)}$$

where $$R(\lambda) = \frac{\sin^2 X}{X^2}(1 + aX^2)$$

and $$X = \min\left[\begin{array}{c}\dfrac{\pi m^2 |\lambda - \lambda_c|}{K} \\ 2.61\end{array}\right]$$

m = echelle order number

λ_c = K/m = central wavelength for order m

a = adjustable parameter

K = echelle grating constant

Current values for K and a are given in Table A-3. Historical variations in these values are found in CSC/TM-81/6117.

Table A-3. Ripple-correction parameters.

Camera	K	a
SWP	137725	0.10
LWR	231150	0.09

Algorithm 9 - Vacuum-to-air wavelength correction:

Since it is customary to catalog wavelengths as measured in air (λ_{air}) in the spectral region longward of 2000Å, IUESIPS makes a vacuum-to-air correction for the appropriate wavelengths measured in the LW spectrograph. These corrections are as follows (see Turnrose and Harvel, 1980).

1. All extracted wavelengths from the SW spectrograph are left uncorrected (vacuum wavelengths λ_{vac}, even for $\lambda_{vac} > 2000$ Å).

2. All extracted wavelengths from the LW spectrograph are corrected to air values if equal to or greater than 2000 Å; extracted wavelengths shorter than 2000 Å are left uncorrected (vacuum wavelengths). When the correction is applied, it is defined by

$$\lambda_{air} = \frac{\lambda_{vac}}{f(\lambda_{vac})} \qquad \text{(A - 15)}$$

$$\text{where } f(\lambda) = 1.0 + 2.735182 \times 10^{-4} + \frac{131.4182}{\lambda^2} + \frac{2.76249 \times 10^8}{\lambda^4} \qquad \text{(A - 16)}$$

Note that in high dispersion, the vacuum-to-air correction described by equations (A-15) and (A-16) is applied after the echelle blaze ("ripple") correction is made. Conversely, when LW spectra are read from tape and ripple-correction processing is to be made, all wavelengths must be transformed back to vacuum values first.

Algorithm 10 - Absolute calibration:

In low dispersion, an absolute calibration of the extracted time-integrated flux (FN) net spectra is obtained by applying the inverse sensitivity function S_λ^{-1} and dividing by the exposure time in seconds. "IUE Data Reduction XII" presents a detailed listing of the S_λ^{-1} function used at GSFC from 9 January 1980 until 3 November 1980; the report by Bohlin and Holm (1980) presents the revised absolute calibration now adopted at both GSFC and VILSPA. The interpolation technique described in "IUE Data Reduction XII" should be used to derive S_λ^{-1} values at intermediate wavelengths. The net flux $F(\lambda)$ is obtained from record 6 of the 7-record merged extracted spectra (Turnrose and Harvel, 1980) and rescaled to floating point format (see algorithm number 10). Alternatively, a new net spectrum could be obtained from a pseudo-slit extraction from the line-by-line spectra (see algorithm number 3). The absolutely-calibrated spectrum $F_{abs}(\lambda)$ is calculated as

$$F_{abs}(\lambda) = \frac{F(\lambda)\, S_\lambda^{-1}}{t_{sec}} \quad \text{erg cm}^{-2}\ \text{s}^{-1}\ \text{Å}^{-1} \qquad \text{(A-17)}$$

where S_λ^{-1} is the inverse sensitivity function in erg cm^{-2} Å^{-1} FN^{-1} for the appropriate camera, and t is the exposure time in seconds.* The value of t may be obtained from logical record 2 of the IUESIPS label (see p. 8-15 of Turnrose and Harvel, 1980), although the value stored there is the sum of the commanded exposure times, and in the case of multiple exposures or multiple-aperture exposures, the appropriate decomposition of that value must be determined from other means. It is recommended that whenever possible, alternative records on the exposure times be consulted to verify or correct exposure times read from the image labels.

In high dispersion, an official absolute calibration is not in use. Recent work in this area is discussed in Cassatella, Ponz, and Selvelli (1981).

* Note: IUESIPS processing does not divide out by the exposure time. See "IUE Data Reduction XII".

Algorithm 11 - Scaling fluxes and wavelengths from integer to real format and vice versa:

Fluxes and wavelengths for IUE spectra are written to the standard Guest Observer (and archive) tape in a scaled integer form. Originally calculated internally as floating-point numbers, these quantities are written on tape as 16-bit integers (range: ± 32767) to facilitate decoding on different computers. The operations required to decode the integer values on tape are given here first. The reverse operations of converting the real values to the integer format are also given.

A. Integer-to-real number conversion

Let I_i be an integer flux value at point i read from tape. Then the corresponding real flux value F_i is obtained from

$$F_i = I_i * J * 2^{-K} \qquad (A - 18)$$

where the J and K scaling constants are read from the scale-factor record of the extracted spectrum being analyzed (see Turnrose and Harvel, 1980, pp. 8-37 ff). Note that each component (gross, background, net, etc.) of a merged spectral file has its own J and K values, pertaining to all orders of that component.

Let $L_i(m)$ be the integer wavelength value at point i in order m read from tape. Then the corrresponding real wavelength value λ in angstroms is obtained from

$$\lambda_i(m) = \lambda_o(m) + UNIT * L_i(m) \qquad (A - 19)$$

where the value of UNIT is 0.2Å in low dispersion and 0.002 Å in high dispersion, and where $\lambda_o(m) = 0$ for low dispersion and is equal to the largest integer less than or equal to the first wavelength in each order; $\lambda_o(m)$ is thus different for each order in high dispersion and is given in the scale-factor record (see Turnrose and Harvel, 1980, pp. 8-37 ff)

B. Real-number-to-integer conversion

With same notation as above,

$$I_i = [F_i/R + 0.5] \qquad (A - 20)$$

where $R = J * 2^{-K}$, and the bracket notation means the largest integer less than or equal to the value contained within the brackets. J and K may be determined as they are in IUESIPS, as shown below:

Let F_{max} be the maximum real flux in the spectrum involved.

Then

$$G = \log_{10}\left(\frac{F_{max} + 1}{32760}\right) \Big/ \log_{10} 2$$

$$L = [G + 0.5]$$

$$D = G - L$$

$$K = 15 - L$$

$$J = [2^{D+15} + 0.5]$$

Finally, for wavelengths $\lambda_i(m)$ in angstroms, in low dispersion $\lambda_o(m) = 0$ and

$$L_i(m) = [\lambda_i(m) * 5 + 0.5] \quad . \qquad (A - 21)$$

In high dispersion, for each order m

$$\lambda_o(m) = \left[\lambda_1(m)\right] \qquad \text{(A - 22)}$$

and

$$L_i(m) = \left[\left(\lambda_i(m) - \lambda_o(m)\right)*500 + 0.5\right] \qquad \text{(A - 23)}$$

Algorithm 12 - Updating scale-factor record of extracted spectra:

The first tape record after the IUESIPS label in all extracted-spectrum files is the so-called scale-factor record (or "record zero"). This record contains a variety of entries relating to the contents of the data records which follow it, including the various important scaling constants such as J,K, and λ_o (see algorithm 11) used to convert integer data on the tape to real numbers; see p. 8-38 of Turnrose and Harvel (1980). In addition, the contents of this record have recently been greatly expanded under the "new" low dispersion software (see "IUE Data Reduction XVIII").

Since this record has been established to hold data in a 16-bit integer format convenient for computer decoding, there are reasons for which the most important entries in the scale-factor record should be updated if the corresponding spectral data are changed as a result of operations the user may perform. These entries would include λ_{min} and λ_{max} values (the nearest-integer minimum and maximum wavelengths of the whole spectrum), the sets of I_{min}, I_{max}, J, and K values for each extracted spectrum where I_{min} and I_{max} are the minimum and maximum scaled-integer flux values, and J and K are the flux scaling constants (see algorithm 11), the λ_o wavelength offsets for each extracted order (again see algorithm 11), and the number of extracted points in each order. All such entries might logically be altered implicitly as a result of spectral manipulations performed by the user, who is, therefore, reminded that these constants should be explicitly updated in the scale-factor record if the user wishes to store the modified spectral data in the standard format for future use or manipulation. Table 8-6 of Turnrose and Harvel (1980) illustrates in explicit fashion the location of all data in the "old" format of the scale-factor record; "IUE Data Reduction XVIII" contains similarly explicit information on the "new" format scale-factor record. Users are directed to these sources to ascertain where the updated entries are to be made.

Algorithm 13 - Updating IUESIPS history labels:

The format of the IUESIPS labels is described in section 8 of Turnrose and Harvel (1980); Figure 8 - 14 of that reference is reproduced here as Figure A - 1. Normal IUESIPS file labels consist of between 20 and 30 physical tape records. Each physical record is 360 bytes in length (one byte = 8 binary bits), being a concatenation of 5 logical records each 72 bytes long. That is, lines in the image label are blocked 5 at a time to form 360-byte physical records (blocks) on tape.

Raw image labels start out 20 physical records (blocks) long. As the image proceeds through the processing system, additional label information is appended, one block at a time. Since the information added at any given step may or may not fill one or more entire block(s), a continuation character at the end of each logical record is used to flag the end of the label as follows. If any logical record is followed by at least one other, the EBCDIC character "C" is placed in byte no. 72 of that logical record to signify a continuation. The last logical record of the whole label contains the EBCDIC character "L" in byte no. 72. Note that the end-of-label flag need not occur on a block boundary; any logical records which appear after the "L" in the last block are undefined (they generally contain core garbage). This overall label-record structure is shown in Figure A-1.

The label records are in a mixture of EBCDIC and binary-integer formats (see Turnrose and Harvel, 1980). Observers using computers with non-EBCDIC printers (e.g., ASCII) are reminded that an input character format conversion will be required to display the EBCDIC portions correctly.

Two special types of files have nonstandard labels: (1) The Tape Header file which begins each GO tape has only 1 block, of which only the first logical record is filled. All information is in EBCDIC format. Note that the Tape Header File label has no "size parameters" field (see Turnrose, Harvel, 1980) as all other labels do. (Note further that the Tape Header File has no data records.) (2) Reseau-position files generated from calibration images have only 1 block in their labels. Unlike the Tape Header file labels, however, reseau-position labels do have the standard size parameters in the first logical record, and generally one or more other logical records are present containing free-form identification information for the source of the reseau data.

If a user wishes to update information within an existing label, he has merely to determine the physical record and byte(s) involved. Figures 8-3 through 8-11 of Turnrose and Harvel (1980) provide detailed format and contents information for normal IUESIPS labels. If a user wishes to add additional records to an existing IUESIPS label, he must first find the last logical record by searching for the EBCDIC "L" in byte 72 (Figure A-1), change the "L" to a "C", and then add additional logical records as necessary, with either continuation ("C") or last ("L") codes in byte 72 of each as appropriate.

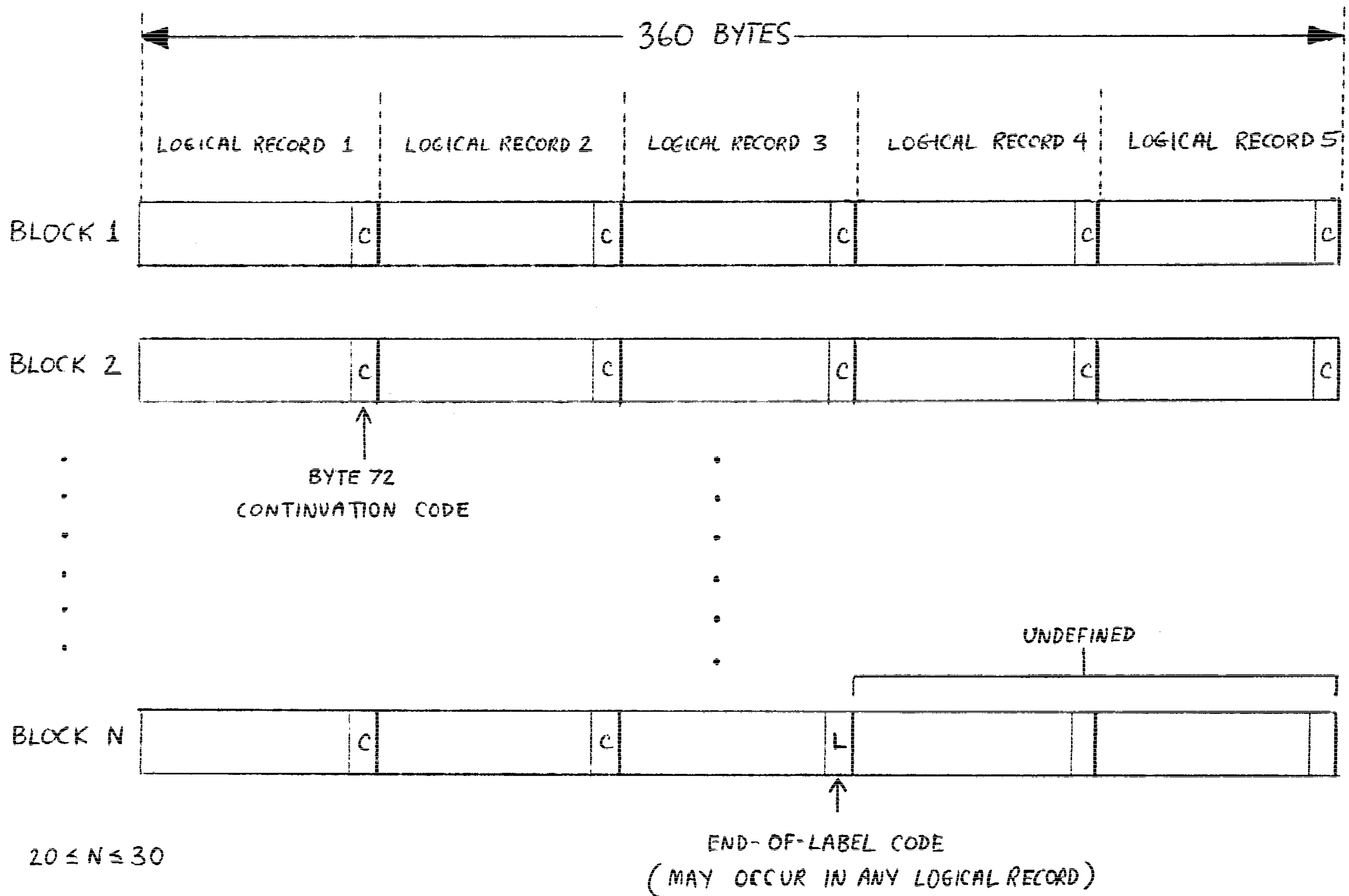


Figure A-1. Standard IUESIPS Label Record Structure

Algorithm 14 - Reading THDA values from IUESIPS label:

Data for the camera head amplifier temperature (THDA) are contained in the so-called "camera snapshot" portion of the IUE image label in binary form. Although prior to March 1979 at GSFC (and a somewhat later time at VILSPA) all of the data necessary to extract THDA usefully were not written in the label, images acquired since that time do contain reliable label entries and THDA is now routinely extracted from the image labels during production IUESIPS processing. In order to utilize the THDA information, one must determine which of a number of time-tagged camera snapshot entries contains the relevant data and then convert the raw telemetry to physical units. Procedures to perform the necessary data retrieval, correlation, and conversion operations have been developed by R.W. Thompson, who has kindly provided the following description of them.

The various data which are read from the IUE image label to determine THDA are listed in Table A-4. The data from logical records 1 and 10 of the label (see algorithm 13) determine the camera, image number, and approximate read time which are in turn used to find the correct entries from among the 15 possible camera snapshot entries in logical records 86-100.

To find THDA at time of READ: Search the camera snapshot entries in records 86-100 to find the entry for which the following three criteria are met:

1) ICAM = TBNO
2) PROC = 7
3) $|TREAD - TCSR| \leq 0.2$ hours, where

$$TREAD = IH + (IM/60.0) + (IS/3600.0) \quad \text{hours}$$

$$TCSR = HR + (MIN/60.0 \quad \text{hours}$$

Then extract the raw THDA telemetry value TLM from byte 41 of that entry, and convert to physical units as described below.

To find THDA at end of exposure: Search backwards through the entries (i.e., backwards in time) from the entry identified above as that pertaining to image READ, until the first entry is found in which:

1) ICAM = TBNO

and 2) PROC = 6

Then extract the raw THDA telemetry value TLM from byte 41 of that entry and convert to physical units as described below. If no such entry is found, then the THDA at end of exposure cannot be extracted from the label; in such cases, the THDA at ime of READ is generally used.

To convert raw THDA telemetry values (TLM) to physical units:

First convert TLM to actual thermistor voltage TV by the relation

$$TV = TLM * 0.02DO \qquad (A - 24)$$

Then convert TV to THDA in ^{o}C using the following polynominal function:

$$THDA = 0.10913\ D03 - (0.13191\ D03)\ (TV) + (0.84903\ D02(TV)^2 - (0.30540\ D02)(TV)^3 + (0.53477\ D01)(TV)^4 - (0.36411\ D00)(TV)^5 \qquad (A - 25)$$

Table A-4 Data read from IUE image label to determine THDA

Parameter Description	Parameter Name	Location: Logical Record No.	Location: Byte No.	Format	Range of Proper Values
Camera number	TBNO	1	50	EBCDIC 1 character	1-4
Image sequence number	ISN	1	52-56	EBCDIC 5 characters	1000-99999
Approximate time of image READ:					
Year-1900	IYR	10	1-2	EBCDIC 2 characters	78-99
Day (GMT)	IDAY	10	3-5	EBCDIC 3 characters	0-364
Hour (GMT)	IH	10	6-7	EBCDIC 2 characters	0-23
Minute (GMT)	IM	10	8-9	EBCDIC 2 characters	0-59
Second (GMT)	IS	10	10-11	EBCDIC 2 characters	0-59
Camera snapshot entries, arranged in 15 logical records (86-100) of 72 bytes each, stored chronologically (with wraparound after 15th entry):					
Time of entry:					
Hour (GMT)	HR	86-100	1	I * 4	0-23
Minute (GMT)	MIN	86-100	2	I * 4	0-59
Raw THDA telemetry	TLM	86-100	41	I * 4	0-255
Camera number	ICAM	86-100	56	I * 4	1-4
Procedure number	PROC	86-100	57	I * 4	1-7

APPENDIX B

"IUE DATA REDUCTION" ARTICLES

Number	Title	NASA IUE NEWSLETTER Number	Date
I.	High Dispersion Data Extraction	2	November 1978
II.	Radial Velocities in High Dispersion Using the Small Aperture	2	November 1978
III.	Accuracy of Low Dispersion Wavelengths	5	July 1979
IV.	CalComp Plots of High Dispersion Net Ripple-Corrected Fluxes	5	July 1979
V.	Wavelength Assignments for Large Aperture Spectra	6	September 1979
VI.	An Outline for Basic Studies of IUE Data and Planned Improvements to the Processed Results	6	September 1979
VII.	Intrinsic Resolution and Planned Changes to the Extraction Slit	6	September 1979
VIII.	Planned Changes to High Dispersion Extraction Slit Height	6	September 1979
IX.	Planned Changes to the Order-Locating Software: DCSHIFT	7	November 1979
X.	Planned Changes to the Background Smoothing Algorithm	7	November 1979
XI.	Mean Dispersion Relations for Low Dispersion Spectra	7	November 1979
XII.	Absolute Calibration of Low Dispersion Spectra	8	February 1980
XIII.	Modification of Photometric Correction to Extrapolate the Intensity Transfer Function	8	February 1980
XIV.	Properties of the Upper Levels of the Intensity Transfer Functions: Extracted DN Values Relevant to Low Dispersion Spectra	9	April 1980

Number	Title	NASA IUE Newsletter Number	Date
XV.	Systematic Errors in the SWP Wavelength Scale	10	June 1980
XVI.	Orbital Velocity Corrections	10	June 1980
XVII.	Mean Reseaux and Dispersion Constants	11	October 1980
XVIII.	Implementation of New Low Dispersion Software: Summary of Output Format Changes	12	January 1981
XIX.	Results of Basic Improvements to the Extraction of Spectra from IUE Low Dispersion Images	12	January 1981
XX.	High Dispersion Line Libraries	13	January 1981
XXI.	The Parameterization of the Motion of the IUE Reseau Grids and Spectral Formats as a Function of Time and Temperature	15	September 1981
XXII.	Washburn Extraction Routine and the Width of the Point Spread Function in Low Dispersion non-GEOM IUE Images	15	September 1981
XXIII.	Further Modifications to the Extrapolation of the Intensity Transfer Function	15	September 1981

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