Chapter 10

High-Dispersion Flux Extraction

10.1 Background Flux Determination (*BCKGRD*)

The determination of smoothed background fluxes is made using the high-dispersion resampled image (SI). A representative high-dispersion SI given in Figure 10.1 shows the echelle orders running horizontally and the spatial (cross-dispersion) direction running vertically. We will refer hereafter to the image sectors at the top and bottom as the “ends” of the image. The background extraction module (*BCKGRD*) produces smoothed background flux spectra which, together with the gross spectra, form the net spectra. The background model is created by computing continuous Chebyshev polynomial functions from pixels that sample valid background fluxes. *BCKGRD* models the backgrounds of images having continuum flux in two one-dimensional passes. For images with no continuum, the algorithm proceeds straightforwardly by sampling the neighboring interorder fluxes for each spectral order and fitting the result to a Chebyshev polynomial. In the sections below, the salient features of *BCKGRD* are described; this process is presented in greater detail in Appendix A.

10.1.1 Pass 1: Cross-Dispersion Swaths

10.1.1.1 Overview

For continuum source images, a series of 25 or 26 nearly equally spaced extraction swaths (slit height of 5 pixels) is made in the spatial direction of the high-dispersion SI, with a starting position at small spatial pixel numbers (short-wavelength end). Except for the first and last few Pass 1 swaths, which form short chords along the left and right edges of the camera image, each swath samples fluxes for nearly the entire range of sample positions; that is to say that they include pixels at the spatial ends of the camera which are not affected by contaminated interorder-overlap flux. The “interorder overlap” flux is described by a Point Spread Function (PSF) model described below. The accumulated effects of overlapping PSFs increase as the orders become more closely spaced. The accumulation causes the interorder overlap to become increasingly severe until the camera sensitivity falls off at short wavelengths. It is this overlap which causes local background extractions in IUESIPS to

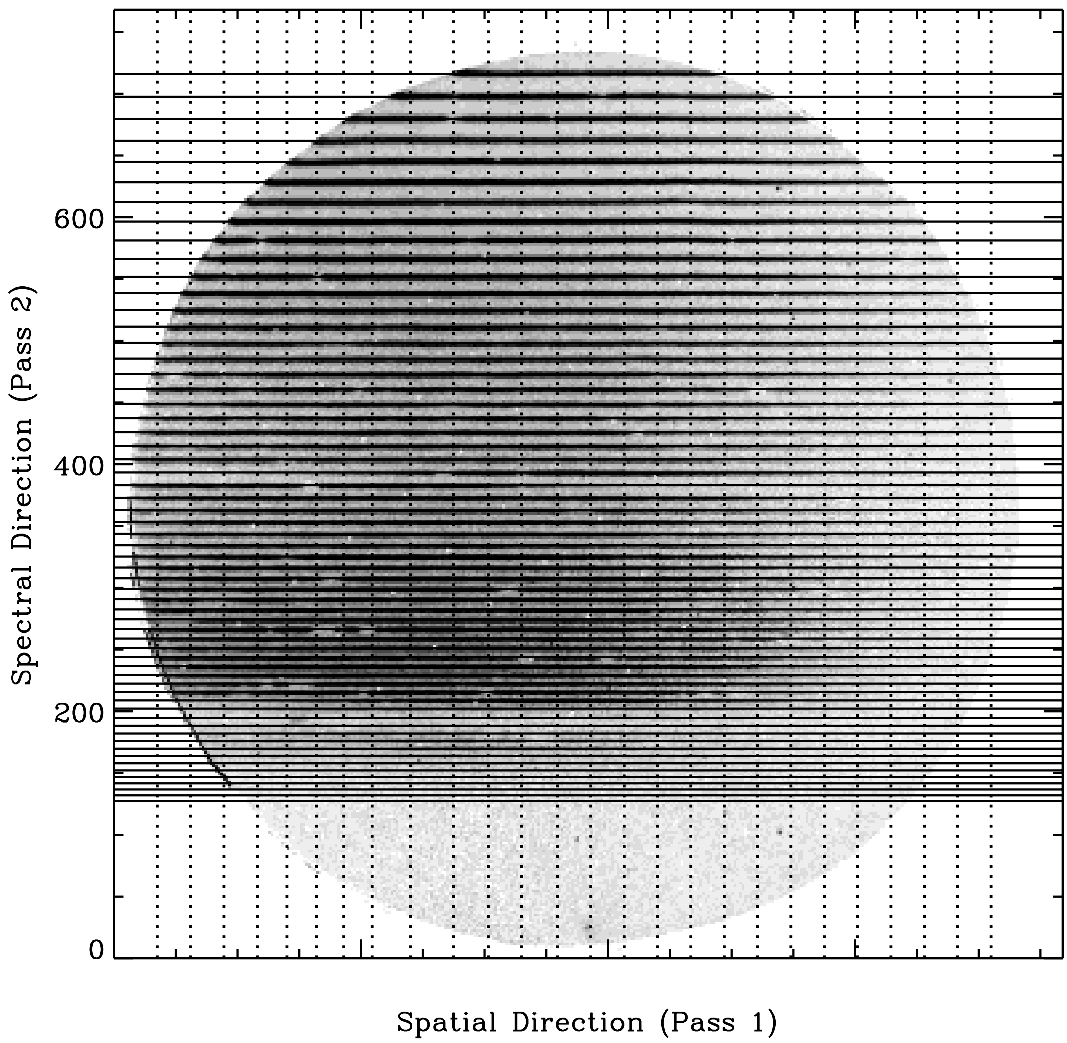

Figure 10.1: Layout of the background extraction swaths on a sample SWP high-dispersion image. Lines running in the vertical (spatial) direction are the Pass 1 extractions. The reconstructed background solutions created in Pass 2 are placed in the positions of the echelle orders (horizontal lines).

be systematically high for short-wavelength orders and which necessitated a strategy for *BCKGRD* to sample background fluxes from distant uncontaminated regions as well as local contaminated ones.

The fluxes sampled from interorder pixels in Pass 1 are modified if they are affected by contamination from neighboring orders. A model PSF provides an initial estimate of how much the fluxes should be offset before the Chebyshev fit is made. The PSF model itself consists of two components, first, a monotonically decreasing function out to about four pixels and, second, a "halation ramp" which extends from four to about seven pixels from the center of each order profile. Each of these components is responsible for order overlap in a particular range of echelle orders. We will refer to the image area where the monotonic portion dominates as the "Interorder-Overlap Region" (IOR). The halation component is actually an extension of the IOR. However, *BCKGRD* treats it separately because, unlike the IOR, its characterization is independent of the order profiles.

The IOR and halation-dominated portions of a Pass 1 swath are indicated in Figure 10.2 for an SWP image. The initially sampled interorder fluxes in both the IOR and the halation regions are revised downward during the course of the calculations. The original and revised "working" fluxes are shown in this plot as squares and small crosses, respectively, and the flux revision for one point is shown as a downward pointing arrow. The final Chebyshev solution for Pass 1 is shown in our example in Figure 10.2 as a continuous undulating line.

10.1.1.2 PSF Modeling Details

The estimate of the contamination of IOR and halation-ramp region fluxes by illumination from the spectral orders proceeds in two steps. Information from the PSF model and from the echelle order fluxes is not used in the first step, nor is a halation overlap region defined. The solution in this "Step 1" of Pass 1 is determined entirely from a Chebyshev interpolation from points in the end (non-IOR) regions of the swath. In the presence of certain image pathologies (described below), as well as for the first and last few Pass 1 swaths, this Step 1 is the only step; it becomes the final solution for the Pass 1 phase.

For the great majority of Pass 1 swaths (i.e., those passing through the middle of the camera image and not encountering poor statistical solutions) *BCKGRD* continues with a Step 2. This step uses the solution from Step 1 as a starting point to compute a PSF-compensated solution in which we attempt to subtract from the measured interorder fluxes the contamination from adjacent orders. Note particularly that there is no adjustment made to correct the *on-order* (gross) fluxes for such contamination.

BCKGRD uses the same trial spatial PSF model for all types of continuum source types in a given camera. The algorithm also assumes that the PSF is global over the image. The model was determined by replicating the accumulation of flux overlap toward short-wavelength orders from a large number of actual images.

The PSF may actually change from image to image. The algorithm attempts to accommodate such changes by using on-the-fly order information to refine the PSF model – specifically the slope of the $\overline{nf\ nd}$ leg of the IOR triangle (see Figure 10.2). This is ac-

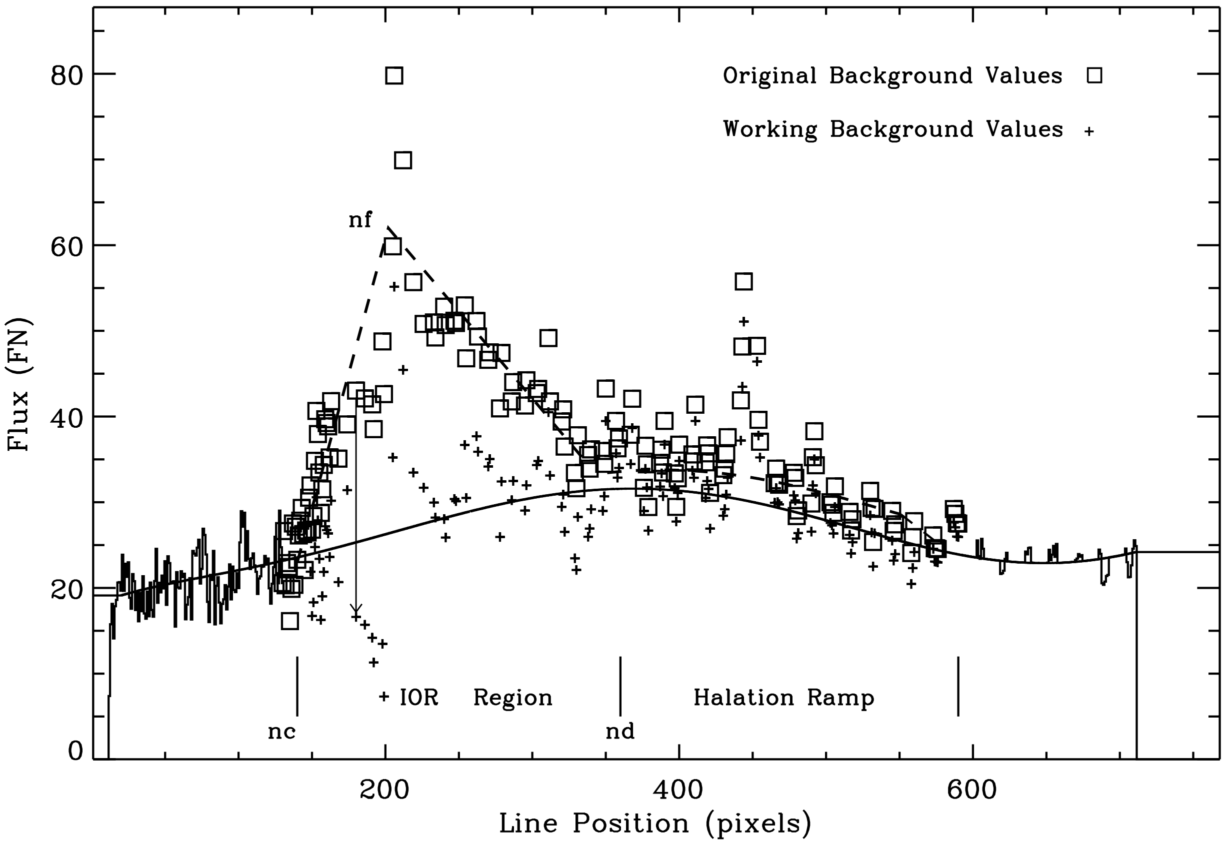

Figure 10.2: Crosscut of background fluxes from a central "Pass 1" swath through an SWP image. Stellar fluxes are off-scale in this diagram. The triangular area describes the local raw background fluxes in the Interorder-Overlap Region where order crowding is severe; the halation region is shown to the right. Small crosses denote the raw fluxes corrected for overlap by the PSF model. The solid line is the Pass 1 solution, a Chebyshev, degree-7 polynomial.

complished by comparing the observed fractional flux overlap with the model result for a reference order within the IOR, that is by comparing the increase in overlap for this order to the overlap found at the start of the IOR (pixel *nd*). If the measured and model slopes agree within a tolerance factor (1.5×), the program adopts the measured slope and scales the model PSF accordingly. Otherwise, the model PSF is used. Tests show that various Pass 1 swaths for a given image can either pass or fail this tolerance test independently.

10.1.2 Pass 2: Dispersion Direction Swaths

In the second operation (Pass 2), inferred background fluxes at the order positions are sampled and assembled as arrays in the spectral direction: the fluxes from the Pass 1 solutions are used to compute a continuous Chebyshev solution for the background at each echelle order position. The generation of a fit along the positions of the echelle orders proceeds with the computation of a 7th-degree Chebyshev function interpolated for all wavelength positions. The Pass 2 operation tends to dilute the effects of poor solutions from a single Pass 1 swath. However, it also introduces a second smoothing into the final background surface.

Figure 10.3 shows a final solution obtained for Order 95 of image SWP20931 on the B0 star HD93222. This order contains a strong Lyman-α feature. The spike pattern indicates samplings from the 26 swaths in Pass 1. A comparison of the residuals (comb pattern in the figure) shows that the solution for the Lyα order is less certain than those for long-wavelength orders where uncontaminated background pixels are common.

10.1.3 Non-continuum images

The existence or absence of continuum flux in an *IUE* echellogram is determined by the order registration module (*ORDERG*). Because interorder-overlap flux can affect background determinations only for continuum images, in the noncontinuum case *BCKGRD* does not go through a Pass 1 step. The background estimates for these images are determined by sampling the interorder background on the long-wavelength side (spatial) of a given order with a one-pixel slit. A 7th-degree Chebyshev solution is then computed for this array of interorder pixels. Note that tests show that some minor contamination from strongly saturated emission lines has been detected in neighboring orders.

10.1.4 Data Pathology Assessments

Occasionally circumstances in the interorder fluxes lead to solutions that are slightly unstable, producing wiggles in an interpolated region that go beyond the flux range of sampled pixels at the two spatial ends of the camera. Such occurrences may be caused by abnormal conditions affecting the image (e.g., target-ring glow, cosmic ray hits, LWR flare, and flux down-turns at camera edge). A series of eight “pathology tests” has been added to *BCKGRD* to protect against blind solutions at the end of Pass 1 which do not agree with simple and often correct interpolations (see Appendix A for full details). These checks generally rely on

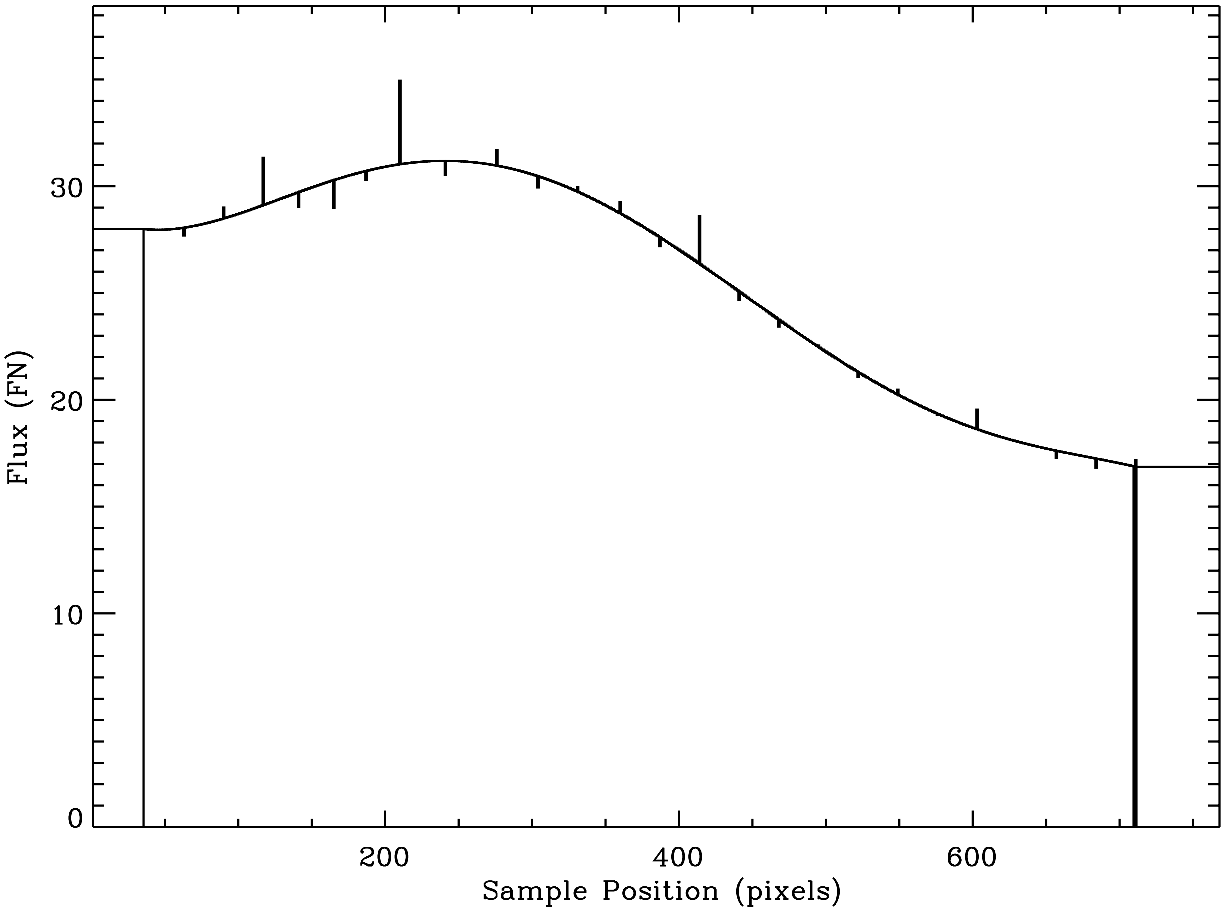

Figure 10.3: Final background solution for SWP20931, Order 95 (smooth solid line). The comb structure connected to the solution reflects the solutions for the various Pass 1 swaths sampled at the line position of this order.

a comparison of fluxes at two or more pixels along the swath or on a ratio of smoothed flux ranges. The rms statistic computed from local raw background fluxes is a convenient unit of measure for flux ranges because it does not rely upon source brightness, exposure time, or an arbitrary flux level. In most cases a failure of a solution in a pathology test causes either the PSF information not to be used in Pass 1, the degree of the polynomial fit to the interorder data to be reduced, or both. Lowering the fitting degree has the effect of removing extra wiggles in the solution; however, the degree of the Chebyshev fit is never reduced below 3. In those cases where superfluous wiggles in the IOR region persist stubbornly after a few trials, a simple linear interpolation is adopted between "good" regions. This may occur for spatial positions toward the short-wavelength (spatial) end of the IOR for certain swaths having reliable background samplings at the target edge. These tests are used only for continuum source images in Pass 1. Therefore, the final output background vectors from Pass 2 are still guaranteed to be pure continuous Chebyshev functions.

10.1.5 Failure Modes

The background swath fitting process is considered to fail if certain conditions apply pertaining to Pass 1 swaths (Appendix A). When this solution fails, the background solution is set to zero for the entire swath. If this occurs for an isolated swath, an interpolated solution from the two neighboring Pass 1 swaths is substituted for the original solution. If two consecutive Pass 1 swaths fail the background arrays for the entire image are set to zero and *BCKGRD* has "given up" on the image. This occurs for about 13 images in the GSFC high-dispersion archives, usually as a consequence of a major portion of the image being missing. This condition is documented in the processing history log.

10.1.6 Caveat

Tests have shown that high-dispersion spectra from each of the three *IUE* cameras have characteristics that impose unique challenges for automated background extraction algorithms. Examples of specific problems are given in Appendix A. The great diversity of image types in the archives prohibits implementing any strategy that makes assumptions about the behavior of source spectra in order to fix isolated background problems, particularly in an automated processing environment. Although the background-extraction algorithm generally provides a good background flux estimate, the results are not always optimal for particular regions of some images. A customized interactive determination of the background fluxes based on individual image characteristics may produce a more accurate estimate of the background in certain cases when data pathologies are present. If users wish to derive a customized background, they should first reconstitute the "gross" flux spectrum by adding the background vector to the net flux vector, multiply the customized vector by the conversion factor between the high-dispersion SI and merged extracted image (MX) fluxes (slit_length*32.0), and subtract this result from the gross spectrum. (In this example, the customized background vector is assumed to have been derived on the basis of a 1-pixel long slit.)

10.1.7 *BCKGRD* Output

The *BCKGRD* module writes the following information to the HISTORY portion of the image label:

- source type (i.e., point or extended) identification for interorder background points and
- background determination method (i.e., continuum or non-continuum) used.

10.2 Spectral Flux Extraction (*EXTRACT*)

The computation of high-dispersion net fluxes in NEWSIPS proceeds straightforwardly with a boxcar extraction. The input data consist of the high-dispersion SI, the high-dispersion resampled ν flag image (SF), the background fluxes determined by *BCKGRD*, and the noise model file. The decision to extract the fluxes with a boxcar weighting scheme means that a rectangular extraction slit is used, giving equal weight to all included pixels except at the very ends of the slit, and that both flagged and non-flagged pixels are used. No attempt is made to exclude flagged pixels in the way that the *SWET* procedure does in low dispersion, because there is no modeling of the spatial profile in a boxcar extraction and hence no knowledge of the relative weight that a "bad" pixel ought to have within the extraction slit. To address the corruption of the flux at a given wavelength by a bad pixel(s) in the extraction slit, NEWSIPS provides a noise vector. This vector may be used as an inverse weight to evaluate the relative uncertainties of computed fluxes with wavelength.

Briefly, the processing steps involved in the boxcar extraction of a series of 1-D spectra (one for each order) from a high-dispersion SI are as follows:

- A 1-D cut across each order is made by extracting fluxes in the spatial direction with a broad swath.
- A centroid position is determined by fitting a gaussian profile to the spatial profile of each order above a locally-defined background level.
- Extraction slit limits are positioned around the centroid position of each order, with fractional begin- and end-line values defining the expected spatial (line-value) limits for capturing 98% of the total flux in the order. These slit heights are fixed functions of camera, source type (point or extended), and order number.
- For each wavelength in every order, the fluxes are summed between the begin- and end-line of the 98% integration limits.
- For each pixel summed across the order, a noise value is determined from the camera noise model.
- The procedure loops through all the echelle orders in this fashion.

10.2.1 Determination of Echelle-Order Locations

The key step in the extraction operation is the determination of the centroid of each echelle order to subpixel accuracy. In principle, the global shifting operation of *ORDERG*, the results of which are incorporated into the high-dispersion SI, accomplishes this same function, but this routine does not always provide the shifting accuracy needed (e.g., for images having weak continua and for extended sources). The input for this refined centroid operation is provided by the high-dispersion SI and SF, the high-dispersion noise model and a set of fiducial line positions for each order which are given in Table 10.1.

The centroid order positions in Table 10.1 were determined empirically for a collection of well-exposed images for each camera. In each case the separations of the initial determinations were compared with echelle grating theory (i.e., they should vary as $1/m_{ech}^2$). The final positions show smooth undulating departures from this distribution amounting to a few tenths of a pixel in most cases.

For each of the echelle orders, fluxes are extracted from a cut in the spatial direction of the high-dispersion SI, summing the fluxes of all "good" (i.e., nonflagged) pixels in a swath between sample positions 150 and 450. The summed fluxes for each spatial line are normalized to a common number of contributing pixels to account for the exclusion of flagged pixels. Next, an rms scatter is computed after excluding points in the spatial profile with significant flux above an initial rms value calculated by including all profile points. A local background is also fit through the low-flux points and subtracted from the profile array. A gaussian model is then cross-correlated through the net-flux profile if there are at least two points with fluxes above the rms value. A default value (i.e., the appropriate fiducial value from Table 10.1) is assigned for the order's centroid position according to any of the following conditions:

- fewer than two spatial profile points have fluxes above the local rms level,
- the centroiding cross-correlation coefficient is unsatisfactory,
- the centroid determined by cross-correlation is beyond a tolerance value (ranging from ± 0.5 to ± 3.0 pixels for short- and long-wavelength orders, respectively) away from the fiducial value.

The shift of the order centroid from the initial assumed value is applied to the end points of the extraction slit. The centroid of each echelle order is found independently with the above steps, effectively centering the boxcar slit on each order.

10.2.2 Description of Spectral Flux Extraction Process

A boxcar extraction slit running along each order is used to extract the spectral fluxes. The length of the extraction slit (listed in Table 10.2 for the various extraction modes) was chosen on the basis of tests with a large group of images to admit a fixed fraction ($\sim$98%) of an order's total flux. This fraction may fluctuate slightly for a given image according

Table 10.1: Fiducial Line Positions for the Echelle Orders

Order No.	LWP Line	LWR Line	SWP Line	Order No.	LWP Line	LWR Line	SWP Line
127	131.04	119.56		96	352.28	343.82	325.32
126	136.34	127.23		95	361.82	353.34	334.43
125	141.95	133.99	128.39	94	371.56	363.11	343.73
124	147.41	139.70	132.99	93	381.50	373.01	353.24
123	153.21	144.50	137.76	92	391.68	383.19	362.95
122	158.98	150.55	142.70	91	402.06	393.50	372.88
121	164.98	156.16	147.82	90	412.71	404.20	383.02
120	171.17	162.81	153.12	89	423.60	415.06	393.40
119	177.12	168.67	158.92	88	434.78	426.14	404.01
118	183.38	175.00	164.80	87	446.18	437.41	414.86
117	189.77	181.49	170.78	86	457.78	449.12	425.96
116	196.22	187.47	176.85	85	469.68	461.04	437.32
115	202.81	194.43	183.02	84	481.90	473.26	448.95
114	209.49	200.80	189.30	83	494.42	485.74	460.85
113	216.16	207.60	195.69	82	507.20	498.52	473.04
112	223.02	214.35	202.20	81	520.30	511.59	485.53
111	229.94	221.02	208.82	80	533.71	525.15	498.32
110	236.97	228.38	215.57	79	547.48	538.83	511.43
109	244.15	235.83	222.45	78	561.57	553.07	524.87
108	251.49	243.17	229.45	77	576.02	567.50	538.65
107	259.02	250.71	236.60	76	590.80	582.49	552.79
106	266.71	258.43	243.88	75	606.01	597.78	567.30
105	274.56	266.13	251.31	74	621.65	613.48	582.19
104	282.57	274.20	258.88	73	637.76	629.57	597.47
103	290.70	282.15	266.60	72	654.42	646.08	613.18
102	298.98	290.53	274.49	71	671.34	662.99	629.31
101	307.43	299.04	282.53	70	688.88	680.35	645.89
100	316.02	307.41	290.74	69	706.53	697.89	662.94
99	324.81	316.31	299.12	68		715.36	680.48
98	333.81	325.30	307.67	67		733.63	698.53
97	342.96	334.44	316.40	66			717.11

Table 10.2: Extraction Slit Lengths for the Echelle Orders - continued on next page

Order	LWP			LWR			SWP		
No.	Lg.	Ext.	Sm.	Lg.	Ext.	Sm.	Lg.	Ext.	Sm.
127	5.14	6.24	5.14	5.14	6.24	5.14			
126	5.14	6.24	5.14	5.14	6.24	5.14			
125	5.14	6.24	5.14	5.14	6.24	5.14	4.72	6.07	4.08
124	5.14	6.24	5.14	5.14	6.24	5.14	4.72	6.07	4.08
123	5.14	6.24	5.14	5.14	6.24	5.14	4.72	6.07	4.08
122	5.14	6.24	5.14	5.14	6.24	5.14	4.72	6.07	4.08
121	5.14	6.24	5.14	5.14	6.24	5.14	4.72	6.07	4.08
120	5.14	6.24	5.14	5.14	6.24	5.14	4.31	6.07	4.08
119	5.24	6.24	5.14	5.24	6.24	5.14	4.06	6.07	4.08
118	5.26	6.24	5.14	5.26	6.24	5.14	4.12	6.07	4.08
117	5.34	6.30	5.20	5.34	6.30	5.20	4.66	6.07	4.08
116	5.46	6.34	5.22	5.46	6.34	5.22	4.66	6.07	4.18
115	5.48	6.40	5.24	5.48	6.40	5.24	4.68	6.07	4.26
114	5.52	6.46	5.29	5.52	6.46	5.29	4.70	6.07	4.36
113	5.56	6.52	5.34	5.56	6.52	5.34	4.70	6.07	4.46
112	5.52	6.58	5.32	5.52	6.58	5.32	4.72	6.07	4.54
111	5.52	6.62	5.32	5.52	6.62	5.32	4.74	6.07	4.64
110	5.60	6.68	5.38	5.60	6.68	5.38	4.82	6.07	4.82
109	5.52	6.74	5.37	5.52	6.74	5.37	4.86	6.07	4.82
108	5.58	6.80	5.42	5.58	6.80	5.42	4.74	6.18	4.76
107	5.68	6.86	5.48	5.68	6.86	5.48	4.70	6.27	4.60
106	5.70	6.92	5.48	5.70	6.92	5.48	4.96	6.38	4.68
105	5.72	6.98	5.52	5.72	6.98	5.52	4.88	6.48	4.76
104	5.74	7.04	5.54	5.74	7.04	5.54	4.84	6.59	4.54
103	5.70	7.10	5.40	5.70	7.10	5.40	4.74	6.69	4.68
102	5.62	7.16	5.34	5.62	7.16	5.34	4.82	6.80	4.60
101	5.58	7.22	5.34	5.58	7.22	5.34	4.82	6.90	4.62
100	5.54	7.30	5.24	5.54	7.30	5.24	4.86	7.01	4.62
99	5.52	7.36	5.18	5.52	7.36	5.18	5.38	7.12	4.96
98	5.42	7.42	5.14	5.42	7.42	5.14	5.06	7.23	4.99
97	5.42	7.48	5.12	5.42	7.48	5.12	5.10	7.34	4.82

Table 10.2: Extraction Slit Lengths - continued

Order	LWP			LWR			SWP		
No.	Lg.	Ext.	Sm.	Lg.	Ext.	Sm.	Lg.	Ext.	Sm.
96	5.44	7.54	5.06	5.44	7.54	5.06	5.20	7.45	4.88
95	5.38	7.62	5.00	5.38	7.62	5.00	5.04	7.56	4.92
94	5.38	7.68	4.98	5.38	7.68	4.98	5.44	7.67	5.22
93	5.44	7.74	5.02	5.44	7.74	5.02	5.28	7.78	4.96
92	5.46	7.82	5.00	5.46	7.82	5.00	5.68	7.90	5.44
91	5.46	7.88	4.96	5.46	7.88	4.96	5.80	8.01	5.60
90	5.54	7.94	5.04	5.54	7.94	5.04	5.86	8.12	5.58
89	5.48	8.02	5.02	5.48	8.02	5.02	6.18	8.24	5.72
88	5.52	8.08	5.08	5.52	8.08	5.08	6.06	8.34	5.87
87	5.56	8.16	5.10	5.56	8.16	5.10	6.27	8.46	6.08
86	5.60	8.22	5.20	5.60	8.22	5.20	6.28	8.60	6.02
85	5.58	8.30	5.14	5.58	8.30	5.14	6.42	8.70	5.92
84	5.64	8.38	5.16	5.64	8.38	5.16	6.46	8.82	6.16
83	5.64	8.44	5.12	5.64	8.44	5.12	6.46	8.94	6.24
82	5.68	8.52	5.22	5.68	8.52	5.22	6.60	9.06	6.20
81	5.78	8.58	5.32	5.78	8.58	5.32	6.62	9.18	6.30
80	5.90	8.66	5.54	5.90	8.66	5.54	6.66	9.30	6.22
79	6.03	8.74	5.74	6.03	8.74	5.74	6.70	9.42	6.28
78	6.18	8.82	5.92	6.18	8.82	5.92	6.86	9.54	6.52
77	6.36	8.88	6.08	6.36	8.88	6.08	6.76	9.66	6.52
76	6.52	8.96	6.20	6.52	8.96	6.20	6.88	9.79	6.50
75	6.66	9.04	6.36	6.66	9.04	6.36	7.02	9.92	6.66
74	6.84	9.12	6.48	6.84	9.12	6.48	7.20	10.04	6.92
73	6.98	9.20	6.68	6.98	9.20	6.68	7.28	10.16	7.10
72	7.01	9.28	6.78	7.01	9.28	6.78	7.62	10.28	7.36
71	7.02	9.36	6.88	7.02	9.36	6.88	7.88	10.42	7.68
70	7.03	9.44	7.01	7.03	9.44	7.01	8.12	10.54	7.96
69	7.03	9.50	7.01	7.03	9.50	7.01	8.32	10.66	8.24
68				7.03	9.50	7.01	8.40	10.80	8.30
67				7.03	9.50	7.01	8.70	10.92	8.46
66							8.84	11.06	8.72

to the actual width of its spatial profile, but it is expected to be the same for orders of a given image. The weights of all pixels, including flagged ones, in the boxcar are the same, except for fractional weights of pixels at the ends of the extraction slit. Thus the fluxes are summed along the slit at each wavelength. To obtain the net fluxes, the background fluxes determined by the *BCKGRD* step are normalized to the extraction slit area and subtracted from the gross spectral flux.

10.2.3 Noise Models

Unlike the processing of low-dispersion images, the extraction of high-dispersion fluxes does not require a noise model. Nevertheless, NEWSIPS provides a noise vector at each wavelength as an indicator of its reliability. This vector is generated by using the camera-dependent high-dispersion noise model (discussed below) to estimate a noise value according to the fluxes along the extraction slit at each wavelength. The total noise amplitude for the wavelength is the sum of the individual noise values of all pixels along the slit, including flagged pixels. In this computation, pixels at the ends of the slit are given their corresponding fractional weights.

The noise models are derived empirically for each camera by measuring the scatter in the FNs around the mean FN in the background regions of several hundred science and flat-field images taken at a variety of exposure levels. These measurements are made in a 21×21 grid of regions, each region being 35 pixels on a side. At each grid point (region), the relation between noise level and FN is fit with a fourth order polynomial. This polynomial is then sampled uniformly at 50 points from 0 to 588 FN, and these sampled noise values for each grid point comprise the "noise model". This positional FN and noise-level information is stored as a static data cube for use in the processing of high-dispersion images. As a given image is processed, the noise level corresponding to a given pixel location and FN value is calculated by interpolation of the noise model data cube: bilinear spatial interpolation is done among the appropriate grid point locations, and linear interpolation in FN is done among the sampled noise values. Noise values for FNs below zero and above 588 FN are set to the noise values corresponding to these extrema, respectively.

Unlike the low-dispersion counterpart, the 1-D noise spectrum which is output to the high-dispersion MX is *not* in absolutely calibrated units. To achieve this, the user should multiply the noise spectrum for a given order by the ratio of the absolutely calibrated flux to the net flux. Although different in detail from the "sigma" vector produced by *SWET* in low dispersion, the high-dispersion noise vector is fundamentally analogous to the sigma vector in its origins from a "noise model" derived from rms measurements of flat fields and in the relationship of its construction to the spectral-flux extraction method used in each case.

10.2.4 One-Dimensional ν Flag Spectrum

The 1-D ν flag spectrum is derived from the flag values in the high-dispersion SF. No attempt is made to screen out flags for pixels which do not contribute a significant enough fraction of the total flux. Consequently, in high-dispersion the final 1-D ν flag value for a given wavelength sample is simply the sum of all unique individual flags for the pixels in the boxcar slit at that wavelength.

10.2.5 *EXTRACT* Output

The main output data product produced during *EXTRACT* is the high-dispersion MX FITS file (MXHI). The MXHI contains the net (background-subtracted) integrated flux spectrum, the Chebyshev-characterized background spectrum scaled up to the extraction slit area, the ν flag spectrum, the ripple-corrected spectrum, the absolutely-calibrated and ripple-corrected net flux spectrum, and the noise spectrum stored in a FITS binary table extension. The net flux, background, ripple, and noise spectra are in units of FN, the flag spectrum is in bit-encoded unitless values, and the calibrated flux spectrum is in physical units of ergs sec^{-1} cm^{-2} $Å^{-1}$. See Chapter 11 for details concerning the process of absolute flux calibration and ripple correction.

The background values for locations before the short-wavelength ends or past the long-wavelength ends of the orders are replications of the first (or last) valid background value. The net flux and noise spectra are computed over the entire wavelength space of the high-dispersion SI, but locations that are outside the camera target area will have net fluxes equal to zero because these regions do not contain any valid image data. The absolute calibrations are valid over wavelength limits of 1150–1980Å for SWP and 1850–3350Å for LWP and LWR. Beyond these limits the calibrated net fluxes are set to a value of 0 and and have a ν flag value of -2. The valid wavelength limits of the calibrated spectra are consequently somewhat truncated as compared to the net flux spectrum.

The *EXTRACT* module writes the following information to the HISTORY portion of the image label:

- noise model version number,
- aperture-dependent extraction/calibration information:
  - slit height information,
  - found line position for a representative "checkpoint" echelle order (i.e., order 100 for the SWP or order 90 for the LWP and LWR). The LWP processing HISTORY initially reported the line position for order 100. This was subsequently changed to order 90 after the start of the processing effort, as this order is a region of higher sensitivity than order 100 for the LWP and LWR. This change only affects LWP and LWR images processed after July 28, 1997.
  - order centroiding warnings (if applicable),

- ripple calibration version number,
- absolute flux calibration derivation information,
- absolute flux calibration version number,
- absolute calibration mode (i.e., point or trailed),
- absolute calibration epoch,
- camera rise time,
- effective exposure time,
- THDA of image,
- reference THDA,
- temperature-dependent sensitivity correction coefficient,
- temperature correction factor,
- time-dependent sensitivity degradation correction version number,
- time-dependent sensitivity degradation correction mode,
- sensitivity degradation calibration epoch, and
- observation date.