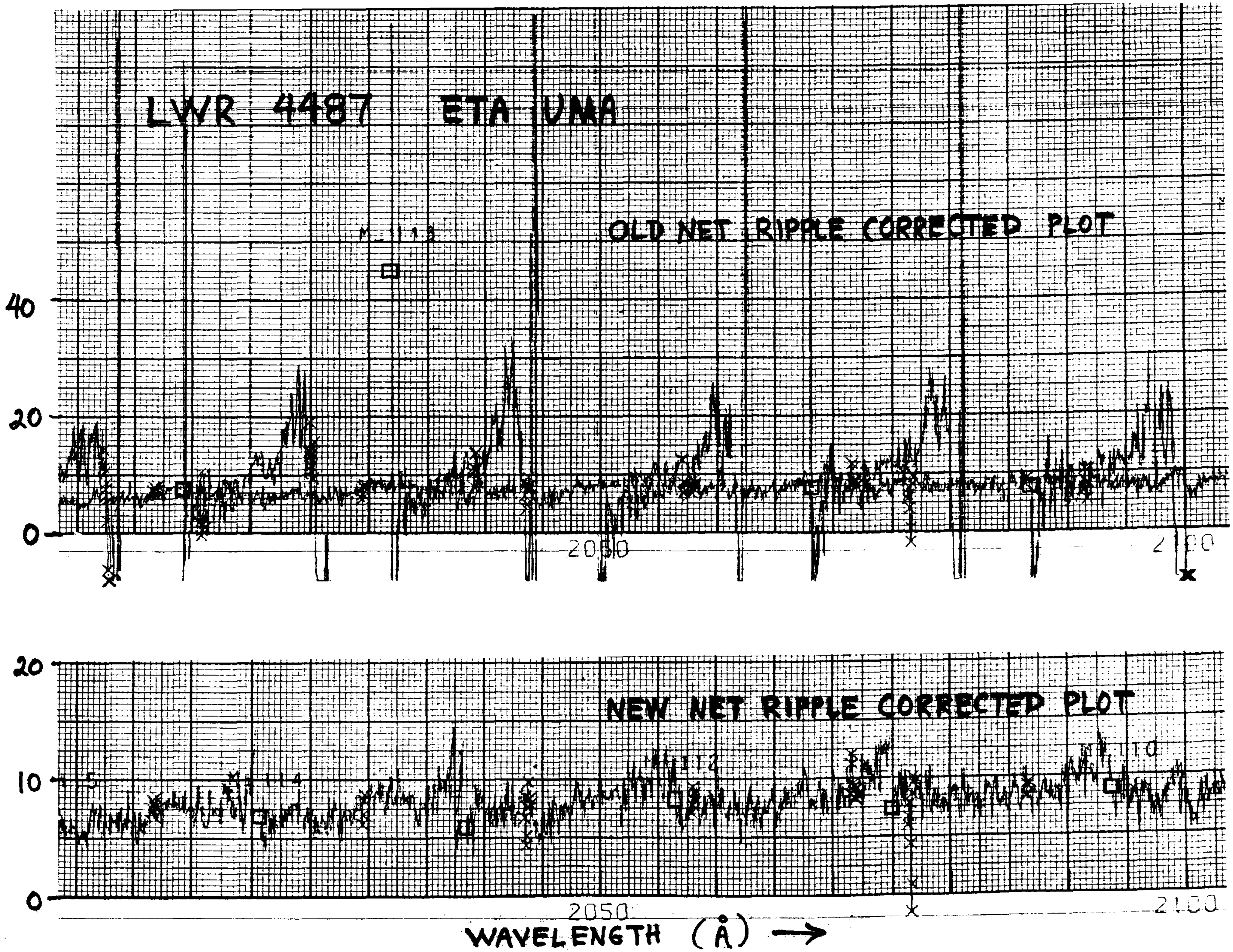
LWR 4487 ETA UMA
OLD NET RIPPLE CORRECTED PLOT
NEW NET RIPPLE CORRECTED PLOT
40
20
0
2050
2100
20
10
0
2050
2100
WAVELENGTH (Å)

FIGURE 1

## III. ACCURACY OF LOW DISPERSION WAVELENGTHS

### 1. CHANGES TO THE Pt-Ne LINE DATA BASE (RELEVENT TO DATA REDUCED PRIOR TO GMT DAY 221 = AUG 9, 1978)

IUE wavelength calibrations are performed using platinum emission-line spectral images which allow a correspondence between wavelength, spectral order, and pixel location to be defined for all spectral formats. All such platinum-line wavelength calibration (WLC) images are processed by the applications program WAVECAL2, which finds the line positions using a specified template and cross-correlation technique and then fits simple dispersion relations to the observed spectral format by regression analysis. Operationally, the dispersion relations are fully described by the set of fitted parameters (coefficients in the dispersion relations) called dispersion constants.

An important ancillary input to the calibration procedure is the so-called "line library," or calibration data base, relevant to the particular mode (dispersion and camera) under consideration. Each line library is comprised of a list of platinum emission lines (each line is designated by an arbitrary identification number generally called simply the "line number") and corresponding laboratory wavelengths and echelle order numbers. The wavelength identifications in the line libraries form the basis for the entire calibration and thus are pivotal quantities. In the following sections, the analyses of these identifications in the various line libraries are discussed.

#### 1.1 Short Wavelength Prime (SWP) Line Library

In low dispersion a linear relationship between pixel location and wavelength is the standard dispersion relation in current use. In this case, the task of wavelength calibration reduces to the fitting of four constants: a zero point and a scale factor for both the image line and sample directions (see Equations 4 and 5). In the specific case of the SWP calibration, the calculated dispersion constants were observed to vary in a more or less random fashion, with the scale factors exhibiting excursions of up to ±2 percent. The nature of these variations, coupled with the relative constancy of the actual locations of the five or six platinum lines measured on each calibration image to provide a starting point for the regression analysis, was indicative of a problem in the data base rather than a genuine variation to the scale of the spectral format. Accordingly, a number of different calibration solutions were analyzed to identify the deficiencies in the line library. As a fiducial, the solution for SWP 2025 was used, it having been previously identified as a reasonably accurate solution on an empirical basis by comparing known wavelengths in spectra of planetary nebulae with the wavelengths assigned by this solution. The scale-factor constants for this solution are as follows:

Sample direction scale factor: -.46732999 Pixels/Å
Line direction scale factor: .37548275 Pixels/Å

The wavelength calibration (WLC) images used in the line library analysis are listed in Table 1 along with the ratios of the computed scale factors to the scale factors for SWP 2025, and the standard deviations ($\sigma$) of the solutions in both the line and sample directions, in pixel units.

Examination of the WAVECAL2 runs for these images showed that in some cases the same pixel positions were calculated for several pairs of blended platinum lines. The lines in these pairs were less than 12 angstroms apart. These lines were subsequently removed from the line library. CalComp plots of an extracted platinum spectrum and photowrite hardcopy images were then examined to determine what additional errors might be present in the line library. The overall results were the following:

- All lines below line 8 were too faint
- Line 15 was contaminated by a reseau
- Lines 19 and 20 were a blend

Table 1. Parameters of SWP Low Dispersion Wavelength Solutions With Original Line Library

| Image Number | Sample Scale Factor Ratio | σ(Sample) | Line Scale Factor Ratio | σ(Line) |
|---|---|---|---|---|
| 1202 | 1.0086 | 3.90 | 1.0130 | 2.80 |
| 1212 | 1.0073 | 3.81 | 1.0078 | 2.96 |
| 1234 | 1.0226 | 3.52 | 1.0223 | 2.44 |
| 1455 | 0.9997 | 3.33 | 1.0007 | 2.48 |
| 1535 | 0.9972 | 0.75 | 0.9984 | 0.65 |
| 1834 | 0.9945 | 2.74 | 0.9930 | 2.15 |
| 2138 | 1.0184 | 1.77 | 1.0176 | 1.53 |
| 2190 | 1.0154 | 1.95 | 1.0166 | 1.73 |

- Lines 24, 25, and 26 were a blend
- Lines 28 and 29 were a blend
- All lines above line 33 were cut off of the SWP image
- Lines 22 and 29 were misidentified, with the correct wavelengths unknown
- Lines 31 and 32 were misidentified, but the correct wavelengths were known

As result of this analysis, lines 15, 19, 20, 22, 24, 25, 26, 28, and 29 were removed from the line library. All lines below line 8 and above line 33 were also removed, and lines 31 and 32 were properly identified. This modified line library gave consistently excellent results, as can be seen in Table 2. Later, it was found that line 32 was used less than half of the time by WAVECAL2, so it too was removed from the line library. Table 3 shows the final SWP low dispersion line library now in standard use.

Test executions of WAVECAL2 were made in order to determine the advisability of allowing terms quadratic in wavelength to enter the dispersion relations in the low dispersion mode, using the new data base. Whereas it had been previously determined that properly executed linear solutions well represent the true dispersion in this mode (note the small standard deviations in Table 2), it was found that the quadratic results were erratic in their agreement with the linear results. On this basis it was determined that quadratic solutions were potentially detrimental and therefore not to be used. Table 4 illustrates the inconsistent results obtained in the quadratic solutions by comparing the predicted line and sample pixel locations corresponding to the wavelengths 1000 Å, 1500 Å, and 2000 Å for the linear and the quadratic cases for the eight WLC images under study. The unreliable results yielded by the quadratic tests are attributed to the inherent instability of extrapolating a quadratic solution well beyond the range of the input data base, particularly at short wavelengths.

### 1.2 Long Wavelength Redundent (LWR) Line Library

There were no known a priori problems with this line library, but it was examined to see if any improvements could be made. Analysis of WAVECAL2

Table 2. WAVECAL2 Results Using Improved SWP Low Dispersion Library

| Image Number | Number of Platinum Lines Used | σ(Sample) | σ(Line) | Sample Scale Factor Ratio* | Line Scale Factor Ratio* |
|---|---|---|---|---|---|
| 1202 | 14 | 0.36 | 0.48 | 0.9976 | 1.0012 |
| 1212 | 14 | 0.30 | 0.31 | 0.9978 | 1.0004 |
| 1234 | 14 | 0.49 | 0.60 | 1.0019 | 1.0015 |
| 1455 | 12 | 0.34 | 0.42 | 0.9980 | 1.0001 |
| 1535 | 11 | 0.59 | 0.52 | 0.9972 | 1.0003 |
| 1834 | 14 | 0.48 | 0.55 | 0.9991 | 0.9983 |
| 2138 | 12 | 0.32 | 0.31 | 0.9964 | 0.9997 |

*Scale Factor Ratio = (scale factor for SWP 2025)/(scale factor for this image).

See Table 6 for the dispersion constants for the images given.

Table 3. Final SWP Low Dispersion Line Library (Used Beginning Aug 9, 1978, GMT Day 221)

| Line Number | Wavelength (Å) |
|---|---|
| 8 | 1380.494 |
| 9 | 1403.896 |
| 10 | 1429.230 |
| 11 | 1482.829 |
| 12 | 1509.288 |
| 13 | 1524.725 |
| 14 | 1554.900 |
| 16 | 1604.010 |
| 17 | 1621.658 |
| 18 | 1635.210 |
| 21 | 1723.128 |
| 23 | 1753.822 |
| 27 | 1812.940 |
| 30 | 1883.051 |
| 31 | 1913.230 |
| 33 | 1971.520 |

Table 4. Comparison of Linear and Quadratic Fits for SWP Low Dispersion

| | Sample Number Linear | | | Sample Number Quadratic | | | Line Number Linear | | | Line Number Quadratic | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Image | λ=1000 | λ=1500 | λ=2000 | λ=1000 | λ=1500 | λ=2000 | λ=1000 | λ=1500 | λ=2000 | λ=1000 | λ=1500 | λ=2000 |
| 1202 | 513.27 | 280.16 | 47.05 | 513.27 | 280.16 | 47.05 | 111.87 | 299.84 | 487.81 | 108.13 | 299.91 | 487.15 |
| 1212 | 513.35 | 280.10 | 47.03 | 512.81 | 280.17 | 47.26 | 112.23 | 300.04 | 487.86 | 111.38 | 300.05 | 487.80 |
| 1234 | 515.32 | 281.22 | 47.12 | 503.23 | 281.54 | 40.58 | 112.58 | 300.61 | 488.64 | 103.39 | 300.53 | 492.45 |
| 1455 | 513.63 | 280.43 | 47.22 | 538.03 | 279.41 | 62.53 | 112.20 | 299.95 | 487.70 | 124.70 | 299.39 | 497.78 |
| 1535 | 513.01 | 279.99 | 46.98 | 555.38 | 279.08 | 96.92 | 112.41 | 300.22 | 488.04 | 81.24 | 300.83 | 449.91 |
| 1834 | 514.61 | 281.16 | 47.71 | 516.99 | 281.10 | 48.05 | 113.03 | 300.45 | 487.88 | 109.62 | 300.53 | 487.39 |
| 2138 | 515.27 | 282.45 | 49.63 | 516.22 | 282.47 | 48.98 | 115.52 | 303.20 | 490.88 | 120.67 | 303.00 | 494.33 |
| 2190 | 513.58 | 281.11 | 48.64 | 490.97 | 281.99 | 30.04 | 113.37 | 301.25 | 489.14 | 133.79 | 300.50 | 504.21 |

runs using this library showed that lines 13, 14, 15, 24, 26, and 30 were never found by the program and that line 38 was almost never found. A CalComp plot of an extracted WLC spectrum and a photowrite hardcopy image were examined, and the following conclusions were drawn:

- Line 14 was misidentified
- Lines 13, 15, and 24 were too faint
- Lines 26 and 30 were blended with other lines
- Lines 38 and 39 were a blend

Consequently, these lines were removed from the LWR low dispersion line library leaving the revised data base listed in Table 5, which was used for production processing beginning on GMT day 221, 1978.

## 2. CORRECTION PROCEDURE FOR OLD SWP LOW DISPERSION CALIBRATIONS

Prior to day number 221 of 1978 the line library used for the SWP low dispersion wavelength calibration was in error, and therefore the wavelengths assigned to extracted data during this period are also in error. In order to correct these wavelengths without reprocessing spectra already extracted a correction formula has been derived, which can be used to obtain corrected wavelengths as a function of (1) the old (incorrect) dispersion constants, (2) the new (correct) dispersion constants, and (3) the old (incorrect) wavelength. The new dispersion constants to be used here are those calculated using the new (corrected) line library (see Section 1.1) and the same platinum calibration image that was used to determine the old dispersion constants. The old dispersion constants needed by the formula are those printed on the CalComp header label, and included in the 360-byte header records on the guest observer tapes.

The correction formula has the following form:

$$\lambda = d + m\lambda_0 \qquad (1)$$

where $\lambda$ and $\lambda_0$ are the new and the old wavelengths respectively and d and m are constants defined in terms of the old and new dispersion constants

Table 5. Final LWR Low Dispersion Line Library

| Line Number | Wavelength (Å) |
|---|---|
| 10 | 1913.230 |
| 11 | 1937.840 |
| 12 | 2037.119 |
| 16 | 2144.920 |
| 17 | 2175.360 |
| 21 | 2290.710 |
| 23 | 2440.797 |
| 25 | 2489.157 |
| 27 | 2539.968 |
| 28 | 2628.815 |
| 29 | 2703.867 |
| 31 | 2734.770 |
| 32 | 2772.490 |
| 33 | 2793.965 |
| 34 | 2830.128 |
| 35 | 2876.430 |
| 36 | 2896.469 |
| 37 | 2930.652 |
| 40 | 3000.790 |
| 41 | 3065.608 |

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

$$d = \frac{b_2 (b_1' - b_1) + a_2 (a_1' - a_1)}{b_2^2 + a_2^2} \qquad (3)$$

where primed values are the old dispersion constants and un-primed values are the new constants. The a's are the dispersion constants defining the location of the extracted pixel in the sample direction and the b's are the analogous constants for the line direction, such that,

$$\text{sample number} = a_1 + a_2 \cdot \lambda \qquad (4)$$

$$\text{line number} = b_1 + b_2 \cdot \lambda \qquad (5)$$

The new and the old set of dispersion constants each define a locus of points (the dispersion line) in the (sample number, line number) plane, which should follow the low dispersion spectral order (see Figure 1). A point on either of these loci has an associated wavelength: $\lambda$ for the new dispersion constants, $\lambda_0$ for the old constants. The wavelength correction formula was derived such that it assigns to a given $\lambda_0$, associated with a point $(s_o, l_o)$ on the old dispersion line, the wavelength $\lambda$, associated with a point $(s, l)$ on the new dispersion line, where the point $(s, l)$ is that point on the new dispersion line closest to $(s_o, l_o)$.

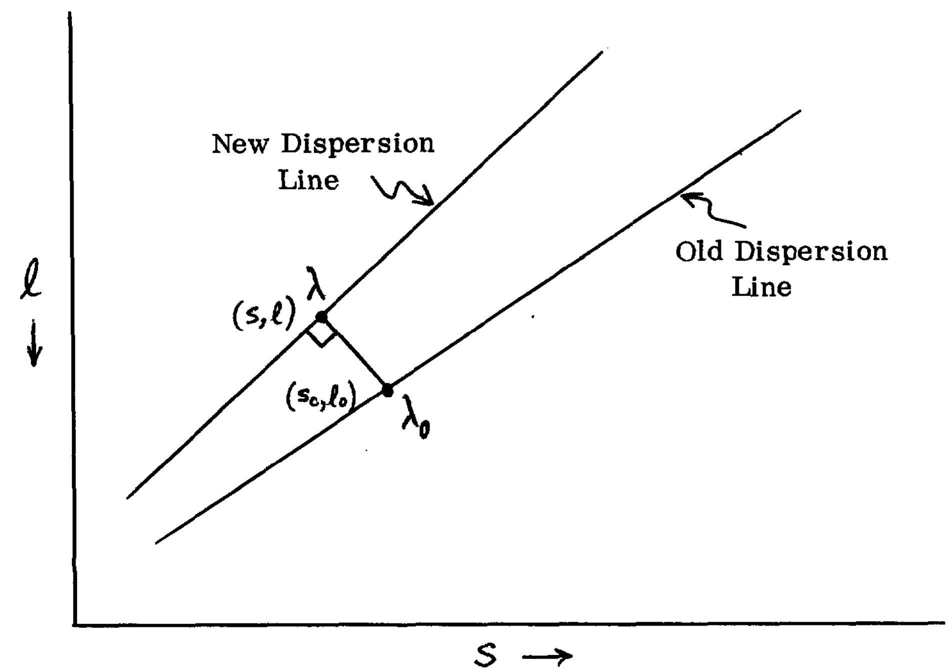


Figure 1. Geometric Relationship of Two Dispersion Lines

Table 6. SWP Low Dispersion Wavelength Calibration

$$\text{Sample \#} = a_0 + a_1 \lambda$$

$$\text{Line \#} = b_0 + b_1 \lambda$$

| GMT Day 1978 | WAVECAL Image | $a_0$ | $a_1$ | $b_0$ | $b_1$ |
|---|---|---|---|---|---|
| 79 | 1202 | 979.495 | -.466224 | -264.070 | .375944 |
| 80 | 1212 | 979.669 | -.466321 | -263.404 | .375634 |
| 83 | 1234 | 983.518 | -.468203 | -263.478 | .376060 |
| 121 | 1455 | 980.043 | -.466409 | -263.297 | .375511 |
| 132 | 1529 | 977.499 | -.465054 | -261.440 | .374445 |
| 133 | 1535 | 979.039 | -.466032 | -263.224 | .375629 |
| 160 | 1753 | 979.946 | -.466045 | -262.341 | .375126 |
| 173 | 1834 | 981.509 | -.466897 | -261.820 | .374851 |
| 181 | 1887 | 979.589 | -.465851 | -260.753 | .374215 |
| 197 | 2025 | 980.347 | -.466428 | -262.048 | .375268 |
| 210 | 2138 | 980.915 | -.465643 | -259.839 | .375365 |
| 216 | 2190 | 978.520 | -.464937 | -262.403 | .375769 |

Note:

1. These dispersion constants were determined using the new line library.
2. These dispersion constants refer to the small aperture. To convert them for use with the large aperture the $a_0$ and $b_0$ terms must be changed as follows:

$$a_0 \text{ (large)} = a_0 \text{ (small)} - 17.1$$

$$b_0 \text{ (large)} = b_0 \text{ (small)} - 19.9$$

When using the correction formula choose the "old" and "new" dispersion constants as follows:

1. Use the dispersion constants from the processing label or the Calcomp label as the "old" dispersion constants since these are the constants that were used to extract the data and assign the "old" wavelengths, and

2. Use the dispersion constants from Table 6 (a complete table of "good" dispersion constants) for the GMT date closest to the date the data image was <u>taken</u> - not the date it was processed.

3. ACCURACY

The accuracy of the correction formula, and the low dispersion wavelengths in general, has been tested by using the formula to correct the wavelengths of planetary nebula emission lines obtained from spectra extracted using several different sets of the "old" dispersion constants. The corrected wavelengths, uncorrected wavelengths and the true wavelengths of the identified lines can then be compared. The results of these tests are presented in Table 7.

Table 7 is broken into the following four main sections: "SWP corrected-known", "SWP measured-known", "LWR corrected-known", "LWR measured-known". The first two columns of the table identify the spectral lines appropriate to each row of the body of the table, while the top row of each section gives the SWP or LWR image numbers appropriate to each column. The values in the body of the table are the wavelength errors in Å found for a given line identified in the given SWP or LWR image. These errors were computed by subtracting the known wavelengths of the lines from the wavelengths measured on the planetary nebula spectra (measured-known), or by applying the correction formula to the measured wavelengths and then subtracting the known wavelengths (corrected-known). The first two rows after the body of the table (labeled "Average Error Each Image = Offset Error" and "$\sigma$ of Offset Error") of all four sections present the average error and the standard deviation of the average error for each SWP or LWR image. This average error

Table 7. IUE Wavelength Accuracy for Low Dispersion

Errors (Corrected–Known) In Å
SWP

| ID | λ (Image #) | SWP 1704 | 1705 | 1707 | 1732 | 1734 | 1741 | Scale Error Each λ | σ of Scale Error |
|---|---|---|---|---|---|---|---|---|---|
| Lα | 1215.67 | -2.59 | -1.24 | -0.79 | -5.42 | +1.59 | +1.04 | -0.61 | 0.58 |
| NV | 1240.1 | -2.62 | +1.37 | | | | | +0.22 | 1.52 |
| OV | 1371.3 | | | | | | +1.21 | +0.37 | |
| NIV | 1486.0 | -1.52 | -0.79 | | | | | -0.31 | 0.77 |
| CIV | 1549.1 | -1.82 | +0.48 | +2.48 | -4.62 | +3.20 | +2.14 | +0.94 | 0.78 |
| NeIV | 1602.0 | -1.42 | | | | | | +0.34 | |
| HeII | 1640.5 | -1.62 | +0.28 | +0.44 | -5.54 | +2.28 | +0.21 | -0.03 | 0.33 |
| OIII | 1666.5 | -2.32 | -0.90 | | -3.88 | +2.33 | +1.87 | +0.24 | 1.02 |
| NIII | 1750.4 | -0.12 | +0.96 | -0.55 | | | | +0.53 | 1.28 |
| CIII | 1908.7 | -1.82 | -1.37 | -0.06 | -7.16 | +1.06 | -1.42 | -1.17 | 0.85 |
| (Average error each image)= (offset error) | | -1.76 | +0.07 | +0.30 | -5.32 | +2.09 | +0.84 | | |
| σ of offset error | | 0.76 | 1.06 | 1.31 | 1.23 | 0.81 | 1.30 | | |

Weighted Mean Offset Error = -0.65 Å σ = 2.20 Å
Weighted Mean Scale Error = -0.05 Å σ = 0.68 Å

1 Å = 0.6 pixel

Errors (Measured–Known) In Å
SWP

| ID | λ | 1704 | 1705 | 1707 | 1732 | 1734 | 1741 | Scale Error Each λ | σ of Scale Error |
|---|---|---|---|---|---|---|---|---|---|
| Lα | 1215.67 | -5.67 | -5.07 | -3.07 | +4.73 | +3.93 | +4.43 | +2.78 | 0.73 |
| NV | 1240.1 | -5.90 | -2.70 | | | | | +2.40 | 1.60 |
| OV | 1371.3 | | | | | | 3.10 | +2.18 | |
| NIV | 1486.0 | -7.00 | -7.00 | | | | | +0.48 | 0.67 |
| CIV | 1549.1 | -7.90 | -6.30 | -2.70 | +2.30 | +2.30 | +2.30 | +1.23 | 0.85 |
| NeIV | 1602.0 | -8.00 | | | | | | -0.05 | |
| HeII | 1640.5 | -8.50 | -7.30 | -5.50 | +0.50 | +0.50 | -0.50 | -0.57 | 0.45 |
| OIII | 1666.5 | -9.50 | -8.70 | | 1.90 | +0.30 | +0.90 | -0.58 | 1.04 |
| NIII | 1750.4 | -8.00 | -7.60 | -6.80 | | | | -0.72 | 0.75 |
| CIII | 1908.7 | -11.10 | -11.30 | -8.30 | -3.70 | -3.30 | -4.70 | -4.16 | 1.00 |
| Mean error each image = offset | | -7.95 | -7.00 | -5.27 | 1.15 | 0.75 | 0.92 | | |
| σ of offset error | | 1.69 | 2.52 | 2.40 | 3.11 | 2.70 | 3.24 | | |

Weighted Mean Offset Error = -3.65 Å σ = 4.05 Å
Weighted Mean Scale Error = -0.05 Å σ = 2.19 Å

1 Å = 0.6 pixel

Table 7. (continued)

Errors LWR

| ID | λ (Image #) | (corrected-known) 1608 | 1609 | Scale Error Each λ | σ of Scale Error | (measured-known) 1608 | 1609 | Scale Error Each λ | σ of Scale Error |
|---|---|---|---|---|---|---|---|---|---|
| CIII | 1908.7 | 4.65 | 1.05 | 0.24 | 0.26 | -4.10 | -2.99 | 1.62 | 3.14 |
| HeII | 2386.0 | 5.05 | --- | 0.82 | --- | -3.00 | --- | -0.50 | --- |
| NeIV | 2426.0 | 2.45 | 2.20 | -0.29 | 2.11 | -6.00 | -5.80 | -1.23 | 1.79 |
| HeII | 2734.0 | 4.25 | 2.21 | 0.62 | 0.84 | -3.40 | -5.40 | 0.26 | 0.23 |
| OIII | 3048.0 | 4.61 | -1.18 | -0.90 | 1.81 | -2.60 | -8.40 | -0.84 | 2.45 |
| OIII | 3133.8 | 2.81 | -0.09 | -1.26 | 0.23 | -4.20 | -7.20 | -1.04 | 0.47 |
| HeII | 3204.0 | 5.81 | 1.81 | 1.20 | 0.54 | -1.20 | -5.20 | 1.47 | 1.18 |
| (Average error each image)= offset | | 4.23 | 1.00 | | | -3.50 | -5.83 | | |
| σ of offset error | | 1.20 | 1.38 | | | 1.50 | 1.85 | | |

(corrected-known):
Weighted Mean Offset Error = 2.39Å σ= 1.68 Å
Weighted Mean Scale Error = 0.06Å σ= 0.88 Å

(measured-known):
Weighted Mean Offset = -4.58Å σ= 1.21Å
Weighted Mean Scale Error = 0.00Å σ= 1.17Å

NB: 1 Å = 0.38 pixel

for each image can be thought of as an "offset" error which can be subtracted from each of the individual errors for that image. The resulting differences represent a combination of random error and errors in scale (a stretching or compression of the wavelength scale). The last two columns of each of the four sections present the mean and the standard deviation of these "scale" errors (TOTAL ERROR MINUS OFFSET) for each emission line.

The last two rows of each section give the weighted mean (weighted proportional to the number of emission lines in each image) and standard deviation for the offset errors and the weighted mean and standard deviation for the scale errors.

The first two sections of Table 7 can be used to compare the errors obtained for the SWP camera before and after the correction is made from the old to the new line library. The test data show a large improvement due to the correction both in mean error and standard deviation. Overall the tests indicate that

1. random zeropoint "offset" errors ($1\sigma$) of about $\pm 2.2$ Å (1.3 pixel) can be expected for the corrected data whereas this error is $\pm 4.1$ Å (2.5 pixel) for the uncorrected data. (It should be noted that the uncorrected data show, in addition to this random error, a large systematic zero point offset due to the bad line library amounting to -3.7 Å or 2.2 pixels, while for the corrected data, the analogous value is -0.65 Å or .39 pixel).

2. "scale" errors ($1\sigma$) of about 0.7 Å (0.4 pixel) can be expected for the corrected data while this error for the uncorrected data is about 2.2 A (1.3 pixels), and

3. "total" errors ($1\sigma$) of about 2.5 Å (1.5 pixels) can be expected for the SWP data where the new line library was used whereas the uncorrected data show a total error of 6.0 Å (3.6 pixels). Total error here is defined as:

$$\sqrt{\sum_{i=1}^{n} r_i^2 / (n-1)} \quad \text{where} \quad r = (\lambda - \lambda_{Known}) .$$

Since the LWR line library was shown to be relatively free of error only two LWR images were measured as a spot test of the calibration for this camera.

For the third section of Table 7 labeled LWR (corrected-known), the correction made was to use as the new dispersion constants a set that was determined from a platinum image taken closer to the time the data image was taken than the platinum image used to determine the old dispersion constants. The test data indicate that:

1. zero point offset errors of about 2.4 Å (average of offsets from LWR 1608 &1609) or 0.9 pixels can be expected for the corrected data whereas this error is 4.6 A or 1.7 pixels for the uncorrected data,

2. scale errors (1 $\sigma$) of about 0.9 Å (0.3 pixels) can be expected for the corrected data while this error for the uncorrected data is about 1.2 Å (0.5 pixels), and

3. total errors (1 $\sigma$) of about 3.5 A (1.3 pixels) can be expected for LWR data after corrections whereas the uncorrected data show a total error of 5.2 A (2.0 pixels).

The number of images and lines measured for the SWP camera is large enough to be statistically significant. It can be seen that there are no large systematic errors for this camera after the wavelength correction whereas there is a systematic offset error (-3.7 Å) and a systematic scale error before the correction. The systematic scale error can be seen by looking at the "scale error each $\lambda$" column for the uncorrected data and noting that the errors get progressively more negative as $\lambda$ increases (going through 0 at about $\lambda$ = 1600 Å).

Since only two LWR images were included in this analysis it is not possible to assign statistical significance to the data. The offset error of -4.58 Å given in Table 7 for the uncorrected LWR data seems to represent a systematic error due primarily to the arbitrary shift applied to the dispersion relation during data extraction. This shift is necessary because thermal shifts of the spectral format occur which cause the dispersion line as defined by the dispersion constants to fall to one side or the other of the actual data to be extracted. The correction routine removes this arbitrary shift.

The values used for the relative positions of the large and small apertures determine the wavelengths assigned to large aperture data (such as the test data presented here). Standard displacements for LWR (those used in production) from the small to the large aperture are: $\Delta L = 19.5$ pixels, $\Delta S = -17.5$, where $\Delta L$ and $\Delta S$ are the displacements in the line and sample directions respectively. Better values of these LWR displacements ($\Delta L = 20.4$, $\Delta S = -19.0$) have recently been determined on the basis of aperture mapping provided by A. Holm, and these will replace the old values in standard production in the near future. The SWP camera reduction procedure uses displacements of $\Delta L = -20$, $\Delta S = -17$ for which new values of $\Delta L = -19.9$, $\Delta S = -17.1$ have now been determined.

If these improved $\Delta L$, $\Delta S$ values are used to determine the dispersion constants for the wavelength correction formula the "corrected" wavelengths obtained will all have a zero point shift which leads to a small degradation in the systematic offset error for SWP (the mean error becomes -0.9 Å instead of -0.7 Å), and a similar degradation for LWR (the errors for the corrected data all increase by 1.3 Å; the mean error thus becomes 3.7 Å or 1.4 pixels).

It should be noted that the planetary nebula spectra used were all taken with the large aperture which may have reduced the accuracy of the wavelengths obtained due to variations in the placement of the nebula in the aperture and in some cases to the irregular structure of the nebula. Smaller errors might be expected if the same tests were made with small aperture data, and therefore the authors would greatly appreciate the assistance of Guest Observers who have taken and reduced small aperture data of emission-line objects.

C. A. Harvel, CSC
B. E. Turnrose, CSC
R. C. Bohlin, GSFC

Code 685
Goddard Space Flight Center
Greenbelt, MD