A Brief History of the ITFs

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I. Introduction

The following note describes briefly the different Intensity Transfer Functions (ITFs) that have been applied to IUE data. This should provide useful background information on these fundamental calibrations and how they relate to your IUE data - which ITF was applied to your data, what absolute calibration goes with the ITF, and whether the data should be reprocessed.

The ITF is the calibration which is used to linearize and flat-field IUE data. It consists of a table of raw data values versus relative intensities, defined for each pixel on the camera. This calibration thus permits the conversion of raw data, or Data Numbers (DNs), to linearized intensity units, or Flux Numbers. The ITF is discussed in more detail in the paper by Bohlin et al. (1980).

The ITF is constructed by combining a series of ultraviolet flood-lamp exposures. A mercury lamp is used to illuminate the cameras with monochromatic light at 2537 A. By appropriate choice of exposure times, a large range of intensity levels may be included. Eleven or twelve levels are chosen in order to define the relation between raw signal (DNs) and intensity. Four or more images are normally combined to reduce the random noise in a given level. Thus a total of 50 or more images are required in order to construct an ITF.

The output of the mercury lamps is not constant*, so standard "exposure meter" images are taken throughout the series of ITF images to monitor the changes in the lamp output. A thorough analysis of the resulting data is performed in order to take this into account and to compute the "effective exposure times" of the images (i.e. the exposure times with lamp degradation taken into account). These exposure times are used to provide a linear intensity scale, which has arbitrary units (Flux Numbers).

Subsequent analysis of spectra of ultraviolet spectrophotometric stars yields the absolute calibration, which is used to convert the intensity units to absolute flux units. The choice of the absolute calibration to be applied to IUE data depends on the ITF used to process the data. The reason for this is that the Flux Numbers produced by each ITF differ, due to the arbitrary scaling of the intensity scale and due to changes in the camera characteristics with time. Thus only the absolute calibration appropriate for a given ITF should be used to calibrate a particular IUE spectrum.

* The rapid degradation and limited lifetime of the UV-flood lamps is the reason why ITF data have been obtained only a few times. Currently the long-wavelength spectrograph lamps, used for the LWP and LWR cameras, operate only sporadically.

II. The Preliminary ITFs

Soon after launch, preliminary ITFs were created for the default short-wavelength and long-wavelength cameras, the SWP and LWR. These ITFs were constructed from a very limited set of UV-flood images, including only one image per level. Both ITFs had 12 levels. These preliminary ITFs, now known as SWP ITF0 and LWR ITF0 respectively, were used in processing data up until May 22, 1978, at Goddard (June 14, 1978, at VILSPA). Because these ITFs were very preliminary, any old data in the archives which were processed with these ITFs should be reprocessed.

The LWP camera was initially used only rarely. Over the first few years after IUE's launch, the UK Resident Astronomers accumulated a number of UV-flood images which were eventually combined to create the first LWP ITF, known as LWP ITF0. Many of the levels included only a single image. There was subsequently some discussion about the effective exposure time assigned to the second level of the ITF. This value was revised, and a new ITF was derived from the same data. This ITF, known as ITF1, has been used to process LWP data until recently. Because the ITF data were rather heterogeneous and sparse, there are some problems with the null level and the noisiness of the ITF. However, the linearity of the ITF is fairly good. There is a small amount of LWP data in the archives processed with LWP ITF0. All early LWP images were reprocessed by VILSPA with ITF1, but LWP images processed by GSFC before November 3, 1981, employed ITF0. The absolute calibration which applies to ITF1 data is given by Cassatella and Harris (1983); see Oliversen (1988) for a discussion of some corrections to the flux scale provided by this absolute calibration.

III. The Original Epoch ITFs

Soon after the initial set of UV-flood images were obtained for the LWR and SWP in 1978, additional UV-flood images were obtained so that improved ITFs could be constructed. The improved ITFs used several (typically four) images per level for the SWP and LWR.

The LWR ITF, known as LWR ITF1, is the one that is currently in use for processing LWR images; it has 12 levels. It was recognized a few years after launch that the LWR ITF was not as linear as it should be; that is, the conversion to intensity units was not quite correct. Various experiments were done to reconstruct the ITF, sometimes using additional UV-flood images, to try to improve it. These attempts did not produce any significant improvement. Later analyses showed that the camera characteristics had in fact changed after the ITF data were obtained so that, in all likelihood, any amount of reanalysis of the old data would not improve the linearity performance of the ITF. The absolute calibration appropriate for this ITF is given by Holm et al. (1982). In addition, Bohlin (1986) discusses some improvements to this calibration.

The SWP ITF, known as SWP ITF1, was found to have an error in the 20 percent level. This occured because a blank image had been inadvertently included with the UV-flood images included in that level of the ITF. A corrected ITF, known as SWP ITF2, was constructed using the same data (except for the blank image, of course). All the SWP high-dispersion data affected by the bad ITF were reprocessed by the IUE Observatory with the corrected ITF. However the low-dispersion data were NOT automatically reprocessed. Thus SWP low-dispersion spectra processed before July 7, 1979, at Goddard (August 7, 1979, at VILSPA) employed the bad ITF and should be either corrected (e.g. SWPFIX at the RDAF) or reprocessed. After this date, the SWP data were processed with the corrected ITF, SWP ITF2. This is the SWP ITF currently in use. Both SWP ITF1 and ITF2 have only 11 levels. Some experiments were done with adding a twelfth level, but no significant improvement resulted. The absolute calibration for these ITFs is given in Holm et al. (1982); see also Bohlin (1986).

IV. The New Epoch ITFs

When the LWR camera developed a flare in its ultraviolet converter in 1983, it became generally appreciated that new ITF data should be obtained for all of IUE's cameras. Thus new sequences of UV-flood images and nulls were obtained for the LWR in November 1983, for the LWP in September 1984, and for the SWP in January-February 1985. The LWR ITF data were obtained first because of the steadily increasing flare in the camera. The techniques involved in the acqusition of the data and the creation of the ITF were more sophisticated than had been used before, taking advantage of what had been learned over the years in both understanding the instrumentation and in creating experimental ITF: better thermal control of the scientific instrument, an extended range of intensity levels, an additional level (i.e. 12 levels) for the SWP ITF, detection and removal of bright spots, careful ultraviolet flood-lamp monitoring, and so forth.

The implementation of a new LWP ITF was chosen to be the first priority, since LWP ITF1 was known to have some deficiencies and the camera had become the default long-wavelength camera in October 1983. The new ITF, known as LWP ITF2, along with its new absolute calibration, was implemented at Goddard and at VILSPA on December 22, 1987. The new absolute calibration is given by Cassatella, Lloyd, and Riestra (1988). See Oliversen (1988) for a discussion of the differences between the old and new absolutely calibrated fluxes.

When the new LWR ITF is implemented, it will be called LWR ITF2. When the SWP ITF is implemented, it will become SWP ITF3. A new absolute calibration has been created for the LWR, and the SWP absolute calibration should be derived in the near future. These new calibrations will probably be implemented in the next 6 to 12 months.

V. Identifying the ITF Applied to Your Data

Table 1 lists the various ITFs and when they were used to process the IUE data. The ITF is most easily identifiable by the effective exposure times of its levels. This information is stored in the first few lines in the image processing portion of the image levels; Figure 1 illustrates this. Table 2 lists the effective exposure times of the levels for each ITF. This table can be used to help identify which ITF was used to process a particular IUE image.

References:

Bohlin, R. C. 1986, Ap. J., 308, 1001.

Bohlin, R. C., Holm, A. V., Savage, B. D., Snijders, M. A. J., and Sparks, W. M. 1980, Astron. Ap., 85, 1.

Cassatella, A. C., and Harris, A. W. 1983, NASA IUE Newsletter No. 23, 21.

Cassatella, A., Lloyd, C., and Gonzalez Riestra, R. 1988, NASA IUE Newsletter No. 35, 225.

Holm, A. V., Bohlin, R. C., Cassatella, A., Ponz, D. P., and Schiffer, F. H. 1982, Astron. Ap., 112, 341.

Oliversen, N. A. 1988, NASA IUE Newsletter No. 35, 55.

Table 1

A Summary of the ITF Processing Dates

	GSFC	VILSPA
SWP		
ITF0	4/3/78 - 5/22/78	4/17/78 - 6/14/78
ITF1	5/23/78 - 7/7/79	6/15/78 - 8/7/79
ITF2	7/8/79 - present	8/8/79 - present
ITF3	(Not yet implemented)	
LWR		
ITF0	4/3/78 - 5/22/78	4/17/78 - 6/14/78
ITF1	5/23/78 - present	6/15/78 - present
ITF2	(Not yet implemented)	
LWP		
ITF0	8/17/81 - 11/3/81	-
ITF1	11/4/81 - 12/21/87	- 12/21/87
ITF2	12/22/87 - present	12/22/87 - present

Table 2

Effective Exposure Times for the ITFs

LWP			LWR		
ITF0	ITF1	ITF2	ITF0	ITF1	ITF2
0	0	0	0	0	0
2023	2300	2723	1800	2303	3501
3969	3969	5429	3700	4069	7193
6062	6062	8145	5600	8008	8909
7790	7790	10955	7500	10073	12474
10256	10256	13640	9400	11878	16202
12982	12982	16336	11200	15883	19820
14850	14850	19235	15000	20149	25404
17900	17900	23198	18800	24471	28781
20562	20562	27397	22500	29391	32505
23379	23379	33186	26300	34333	40168
32973	32973	38389	30000	42032	48979

Notes:

LWP ITF0 = early epoch, one image per level

LWP ITF1 = same as ITF0 with revised second level exposure time

LWP ITF2 = several images per level, epoch, 1984

LWR ITF0 = early 1978, single image per level

LWR ITF1 = several images per level, epoch 1978

LWR ITF2 = not yet implemented, several images per level, epoch 1983

Table 2 (cont.)

SWP			
ITF0	ITF1	ITF2	ITF3
0	0	0	0
1800	1753	1684	1695
3600	3461	3374	3498
5500	6936	6873	5363
7300	9000	9091	6766
9100	10575	10586	8563
10900	14299	14371	11484
12700	17709	17745	14021
14500	21546	21524	17531
18200	25156	25105	20784
21800	28674	28500	24393
29100			29658

Notes:

SWP ITF0 = early 1978, single image per level

SWP ITF1 = incorrect 20% level, several images per level, epoch 1978

SWP ITF2 = corrected, several images per level, epoch 1978

SWP ITF3 = not yet implemented, several images per level, epoch 1985

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     6    1 -  -              A6   \ R    ,      /                          100  C
*GEOMF    18:03Z APR 26,'79                                                    HC
**********   GEOM. & PHOTOM. CORRECTED IMAGE **********                        C
PCF C/** DATA REC. 11 1   1   1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
          0       1753       3461       6936       9000      10575   1PC
      14299      17709      21546      25156      28674                1PC
     11.000     11.000     11.000     11.000     11.000     11.000    1PC
     11.000     11.000     11.000     11.000     11.000               1PC
TUBE   3 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0           1PC
     C     MODE : FACTOR   .178E 00                                     1PC
*FICOR5   18:03Z APR 26,'79                                             HC
**********  DATA FROM LARGE APERTURE  *********                          C
*EXTLOW   18:03Z APR 26,'79                                             HC
@EXTLOW: OMEGA=  90.0, HBACK=  5, DISTANCE= 11.0                         C
        :HT= 9, DC$=   1; ISN:     0 PSN      1 SIGS=  .422 SIGL=  .420C
B 1= -.283889899727D 03 B 2=  .376160163031D 00 B 3=  .000000000000D 00C
A 1=  .963611817183D 03 A 2= -.466031994415D 00 A 3=  .000000000000D 00C
LINE SHIFT =   .000     SAMPLE SHIFT =   .000                            C
*SMOOTH   18:03Z APR 26,'79                                             HC
*ARCHIVE   18:03Z APR 26,'79                                            HC
*ITOE   18:03Z APR 26,'79                                               HC
****** FILE OF MERGED EXTRACTED SPECTRA *****                            C
*** GROSS, BACKGROUND, NET & ABSOL. CALIB. NET ***                       C
*ETOEM   18:03Z APR 26,'79                                              HC
*ARCHIVE   18:03Z APR 26,'79                                            HL
IUE_IDL>
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Figure 1. Image processing header for SWP 4961, processed with the bad SWP ITF.