Linearity of Low Dispersion Spectra Processed with the New SWP ITF

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I. Introduction

Observations for the new SWP ITF (ITF3) were obtained on January 29 through February 1, 1985. Standard star spectra, processed with the new ITF, have been analyzed to study the linearity errors of non-optimum exposures. The observational and analysis techniques are briefly summarized in section II. The differences between optimum trailed spectra when processed with either ITF3 or ITF2 are discussed in section III. In section IV we will discuss the linearity of non-optimum trailed spectra. The linearity of non-optimum point source spectra will be discussed in section V, and trailed spectra with high backgrounds are looked at in section VI.

II. Observation and Data Analysis Techniques

The observation and analysis techniques used for this study are similar to the method used in Oliversen (1983, 1984a, and 1984b). The standard star HD 60753 is routinely observed for linearity monitoring twice per year. This monitoring sequence typically consists of an initial optimum (100%) trailed exposure followed by a series of under- and over-exposed trailed spectra and terminates in a final optimum exposure. For this study point-source spectra of BD +28° 4211, and point-source and high background trailed spectra of HD 74604 were also analyzed. HD 74604, an B8V star, was observed because it was conveniently located close to the attitude of the ITF observations. For comparison, each image has been processed with both the current and new SWP ITFs.

As in the last linearity report (Oliversen 1986), the linearity errors were determined by ratioing a test exposure to the average of the two 100% exposure level images when both were available. If two 100% exposure level images were not taken, the test exposure was ratioed to a single 100% spectrum. Each spectral ratio is corrected for the camera head amplifier temperature-induced sensitivity changes (Sonneborn and Garhart, 1987), and is then smoothed with a 5 point median filter and with an 11 point boxcar filter. The resultant ratios are plotted for both the current and new SWP ITFs.

Figures 1a and 1b show the image processing portion of the labels for ITF2 and ITF3 images, respectively. The region of the label marked with a bracket represents the effective exposure times (in units of 0.01 seconds) of each level of the ITF. The effective exposure times are different for the two ITF's. The labels can therefore be used to determine which ITF an individual image has been processed with by inspection of the effective exposure times.

III. ITF3 Versus ITF2 for Optimum Trailed Spectra

A sample plot of an optimum trailed exposure of HD 60753, processed with both the old and new ITF, is shown in Figure 2. Optimum spectra processed with ITF3 divided by the same spectra processed with ITF2 are shown in Figures 3a-3b and were binned in 25 Å bandpasses (see Table 1). The first two spectra listed in Table 1 are trailed and the last is a point source spectrum. The derived fluxes processed from ITF3 are 4-10% lower than those of ITF2 over the entire spectral range for trailed spectra, and 4-9% lower for the point source spectrum. Therefore, a typical spectral image processed with ITF3 and the current absolute calibration, which is based on ITF2, can be expected to have total errors across the spectrum of about 10%. (Note: ITF3 is not yet used in processing GO tapes and will probably not be used until the new absolute calibration is available.)

IV. Non-Optimum Trailed Spectra

The flux ratios for two under-exposed and one over-exposed spectra processed with both ITFs are shown in Figures 4a-b and 5, respectively. There is only a slight improvement in the linearity with the new ITF.

The recent 40%/100% ITF3 ratios are slightly improved, particularly at the short wavelength end. Between 1250 and 1450 Å the fluxes derived from processing with ITF2 are too low relative to an optimum exposure by 4-6%, while those derived from processing with ITF3 are too low by 1-3%. Between 1850 to 1950 Å the fluxes derived from ITF2 are too high relative to an optimum exposure by about 2-4%, while those derived from ITF3 are very close to the optimum exposure value. The ITF3 image fluxes appear to be slightly "flatter", or more uniform than the ITF2 image.

The 40%/100% flux ratio of the older image is shown in Figure 4b. There does not appear to be any significant difference between the linearity of spectra processed with ITF3 or with ITF2. Both ITF's yield fluxes which are too low by about 3-5% at the shorter wavelengths, while and both are too high by about 3-5% at the longer wavelengths.

The 120%/100% flux ratio is shown in Figure 5. There does not appear to be any major difference between the linearity of the spectra processed with ITF3 and with ITF2. Both appear to correct the data equally well.

V. Non-Optimum Point Source Spectra

The flux ratios for non-optimum point-source spectra processed with ITF2 and ITF3 are shown in Figures 6a-b and 7. As with the non-optimum trailed spectra, there is only a slight improvement in linearity with ITF3.

Figure 6a shows a 52%/100% flux ratio for a relatively recent image. There is some improvement at the short wavelength end between 1250 and 1400 Å. The ITF2 fluxes yield errors of 6-8% while the ITF3 fluxes yield errors of 4-6%.

The 58%/100% flux ratio for an older image (Figure 6b) also shows some improvement at the short wavelength end from 1250 to 1350 Å. The ITF3 derived fluxes are too low by 4-6% as opposed to 6-9% for ITF2.

The 133%/100% flux ratio for a point source image is shown in Figure 7. As was seen with the trailed over-exposed images, there is no significant change between the linearity of ITF2 and ITF3.

VI. High Background Spectra

Figures 8a-b illustrate linearity errors for spectra obtained with high backgrounds. These images were produced by exposing the camera to a trailed stellar image and then exposing the camera to empty sky to build up the radiation-induced background level. These high background spectra provide an approximate measure of the linearity of spectra obtained during the US2 shift, when the field particle (FPM) levels are often high. The radiation background images had a maximum average continuum level of 168 DN and a background level of 96 DN. Figure 8a shows the flux ratio of a (30% + FPM)/100% trailed image. The only improvement in linearity is at the long wavelength end between 1600 and 1850 Å where the ITF2 fluxes are 1-4% too low and the ITF3 fluxes are 0-2% too low. However, these differences may not be significant given how noisy the images are. Figure 8b shows the ITF3 and ITF2 (27% + FPM)/100% flux ratio's. The results are similar to Figure 8a.

VII. Discussion

As might be expected, the main improvement in linearity occurs for recent images, which were taken near in time to the ITF3 observations. Both trailed and point-source under-exposed spectra are slightly improved with ITF3. High background images may also be slightly improved with ITF3, although it is difficult to be certain given the noisy data. Recent over-exposed spectra and older spectra show no significant differences when processed with ITF2 or ITF3. Overall, there does not appear to be a large difference in linearity between images processed with ITF2 and ITF3.

These results may be consistent with the preliminary findings of the recent Signal-to-Noise workshop, suggesting that the ITF's may not be properly alligned with the raw images during production processing. For many IUE images the background levels are too low to locate the reseaux (with the standard reseaux finding routines) and use them to geometrically correct the images. Consequently, IUESIPs uses a program (TCCAL) to predict where the reseaux are located, based upon time, temperature and DN levels of the image. It is possible that the predicted reseau positions are in error by a small amount. Misregistration on the sub-pixel level might be sufficient to introduce misallignment noise. Several groups at Goddard are investigating various methods of trying to improve the allignment of the ITF with the raw images. Once an improved allignment algorithm is available, it would be interesting to reprocess these test images and repeat these linearity tests to see if the errors are reduced.

References

Oliversen, N. A. 1983, "NASA IUE Newsletter", No. 23, p. 31.
Oliversen, N. A. 1984a, "NASA IUE Newsletter", No. 24, p. 27.
Oliversen, N. A. 1984b, "NASA IUE Newsletter", No. 24, p. 50.
Oliversen, N. A. 1986, "NASA IUE Newsletter", No. 31, p. 52.
Sonneborn, G. and Garhart, M. 1987, "NASA IUE Newsletter", No. 33, p. 78.

Table 1

Binned Flux Ratios for 100%(ITF3) / 100%(ITF2)

Central	DAY 68 1985			DAY 29 1985
Wavelength	SWP 25404	SWP 25408	R(AVG)	SWP 25009
1250	0.904	0.903	0.903	0.910
1275	0.904	0.905	0.904	0.913
1300	0.934	0.927	0.930	0.938
1325	0.918	0.918	0 918	0.924
1350	0.911	0.908	0.910	0.914
1375	0.918	0.915	0.916	0.923
1400	0.924	0.923	0.924	0.919
1425	0.928	0.927	0.927	0.930
1450	0.922	0.920	0.921	0.915
1475	0.916	0.917	0.916	0.920
1500	0.928	0.928	0.928	0.918
1525	0.930	0.928	0.929	0.926
1550	0.926	0.927	0.927	0.923
1575	0.925	0.925	0.925	0.912
1600	0.925	0.925	0.925	0.931
1625	0.932	0.932	0.932	0.929
1650	0.938	0.937	0.938	0.936
1675	0.937	0.938	0.938	0.933
1700	0.939	0.939	0.939	0.930
1725	0.941	0.941	0.941	0.935
1750	0.947	0.947	0.947	0.941
1775	0.947	0.948	0.948	0.946
1800	0.956	0.958	0.957	0.957
1825	0.951	0.949	0.950	0.941
1850	0.953	0.954	0.954	0.942
1875	0.951	0.953	0.952	0.941
1900	0.955	0.952	0.953	0.945
1925	0.957	0.958	0.958	0.945
1950	0.954	0.954	0.954	0.944

```
     ***** SCHEME NAME: T3LTAC *****                                           C
Eff. PCF C/** DATA REC. 11 1    1    1 768 8448 5 3  6.1   5.0 2536    .00000 1PC
Expo.--[     0        1684       3374       6873        9091       10586    1PC
       [_ 14371       17745      21524      25105       28500                1PC
Time     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
     *PHOTOM   13:30Z MAR 11,'85                                              HC
     **********  DATA FROM LARGE APERTURE **********                           C
     *SPECLO   13:30Z MAR 11,'85                                               C
     OBSERVATION DATE(GMT): YR=85  DAY= 68  HR=11  MIN=28                      C
     TARGET COORD (1950) :  RT. ASC.= 7 32  8.1  DECL.=-50 28 29               C
     OPTIONS :HT=15,  HBACK=  5,  DISTANCE= 11.0,  OMEGA=  90.0                C
     MEAN RESEAU  (GMT= 78.085-79.334 NO. FF= 18 SIGS= .134 SIGL= .138 PX)    C
     MEAN DC  (GMT= 78.274-84.071  NO. WLC= 107  SIGS= .254 SIGL= .231 PX)    C
     B 1= -.2824092049336D 03 B 2=  .3762166817767D 00 B 3=  .0000000000000D 00C
     A 1=  .9677807366683D 03 A 2= -.4665747674620 00 A 3=  .0000000000000D 00C
     THDA FOR RESEAU MOTION =  8.84                                            C
     THDA FOR SPECTRUM MOTION =  8.84                                          C
     THERMAL SHIFTS:   LINE =   .478   SAMPLE =  1.749                         C
     REGISTRATION SHIFTS:   LINE =   .136  SAMPLE =   .110   AUTO              C
     *POSTLO   13:30Z MAR 11,'85                                              HC
     ****MERGED SPECTRA- GROSS, BACKGROUND, NET, & ABS. CALIB. NET             C
     *ARCHIVE   13:30Z MAR 11,'85                                             HL
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Figure 1b. Label for ITF3

```
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     ***** SCHEME NAME:  T3LTAC *****                                          C
Eff. PCF C/** DATA REC. 12 1    1    1 768 9216 5 3  6.1   5.0 2536    .00000 1PC
Expo.--[     0        1695       3498       5363        6766        8563    1PC
       [_ 11484       14021      17531      20784       24393       29658    1PC
Time     11.000      11.000     11.000     11.000      11.000      11.000    1PC
         11.000      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
     *PHOTOM   12:33Z JUN 29,'88                                              HC
     **********  DATA FROM LARGE APERTURE **********                           C
     *ESPECL   12:33Z JUN 29,'88                                               C
     OBSERVATION DATE(GMT): YR=85 DAY= 68 HR=11 MIN=28, (JD): 2446133.9778    C
     TARGET COORD (1950) :  RT. ASC.= 7 32  8.1  DECL.=-50 28 29               C
     OPTIONS :HT=15,  HBACK=  5,  DISTANCE= 11.0,  OMEGA=  90.0                C
     MEAN RESEAU  (GMT= 84.007-84.204 NO. FF= 94 SIGS= .158 SIGL= .166 PX)    C
     MEAN DC  (GMT= 78.274-84.071  NO. WLC= 107  SIGS= .254 SIGL= .231 PX)    C
     B 1= -.2826671680057D 03 B 2=  .3762166817767D 00 B 3=  .0000000000000D 00C
     A 1=  .9675727355546D 03 A 2= -.4665747674620 00 A 3=  .0000000000000D 00C
     THDA FOR RESEAU MOTION =  8.84                                            C
     DN FOR RESEAU MOTION =  50  ( 59, 70, 66, 78)                             C
     THDA FOR SPECTRUM MOTION =  8.84                                          C
     THERMAL SHIFTS:   LINE =   .478   SAMPLE =  1.749                         C
     REGISTRATION SHIFTS:   LINE =  -.122  SAMPLE =  -.098   AUTO              C
     *POSTLO   12:33Z JUN 29,'88                                              HC
     ****MERGED SPECTRA- GROSS, BACKGROUND, NET, & ABS. CALIB. NET             C
     *ARCHIVE   12:33Z JUN 29,'88                                             HL
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Figure 1a. Label for ITF2

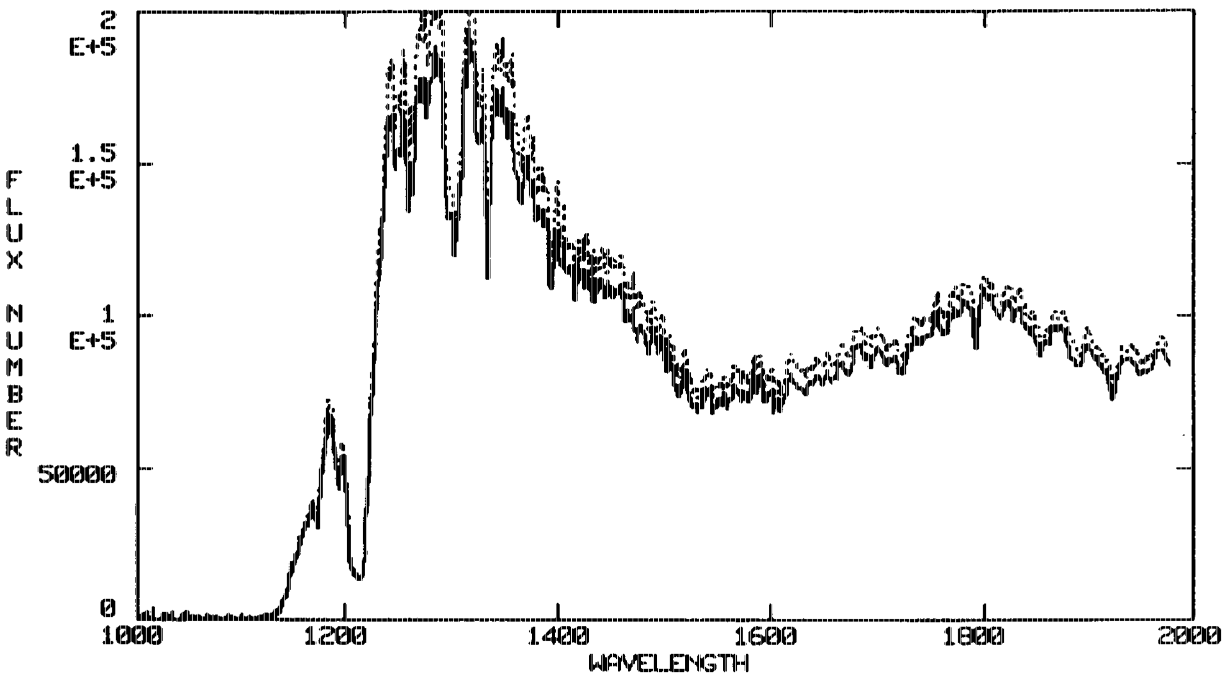


Figure 2

HD 60753 100% Trailed Spectra
SWP 25404 DAY 68, 1985
DOTS = ITF2 LINE = ITF3

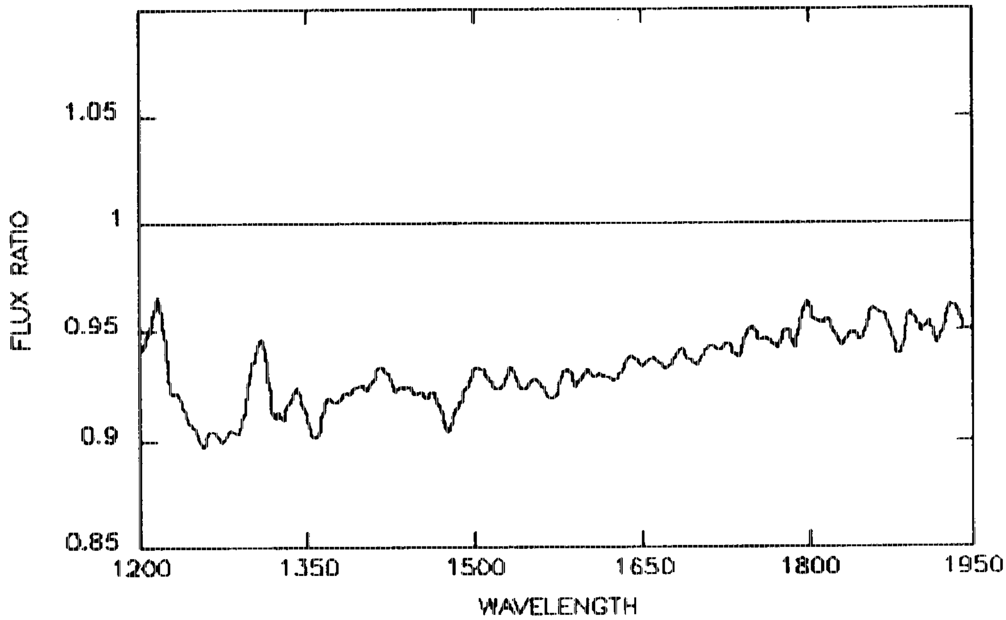


Figure 3a

100% (ITF3)/100% (ITF2)
SWP 25404 TRAIL
DAY 68, 1985

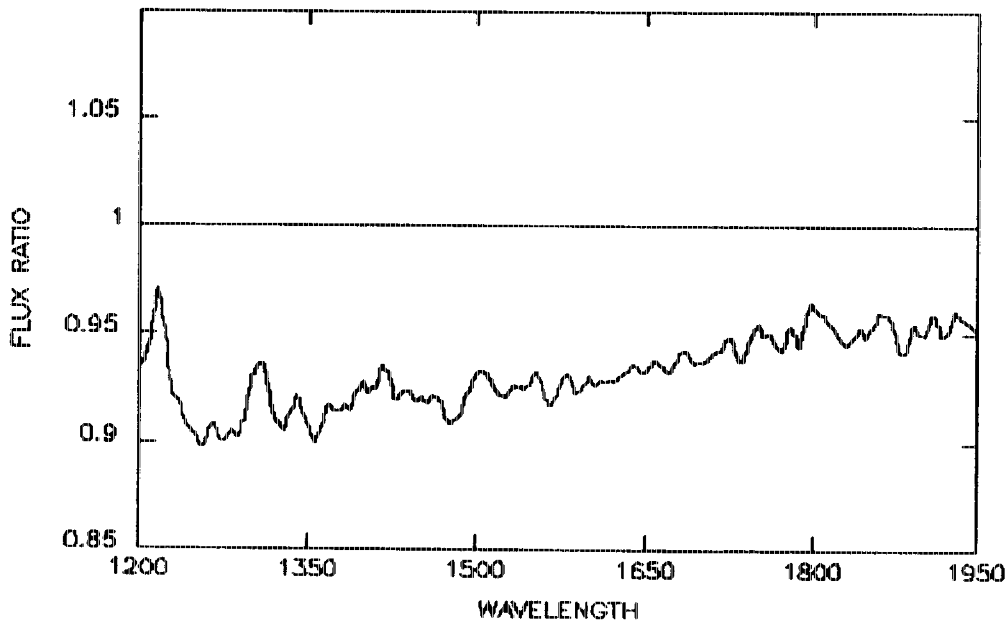


Figure 3b

100% (ITF3)/100% (ITF2)
SWP 25408 TRAIL
DAY 68, 1985

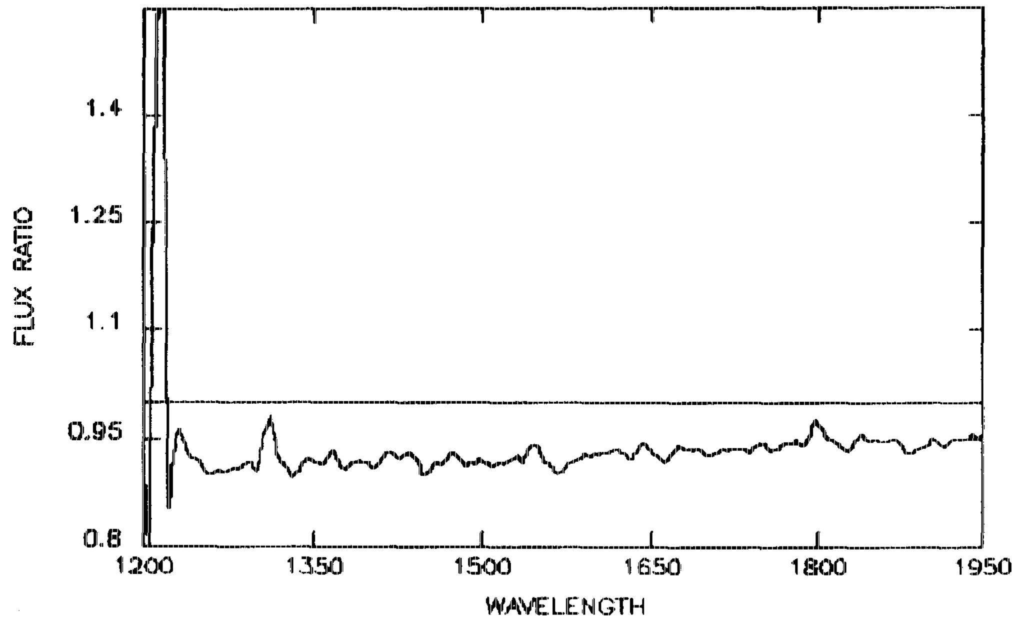
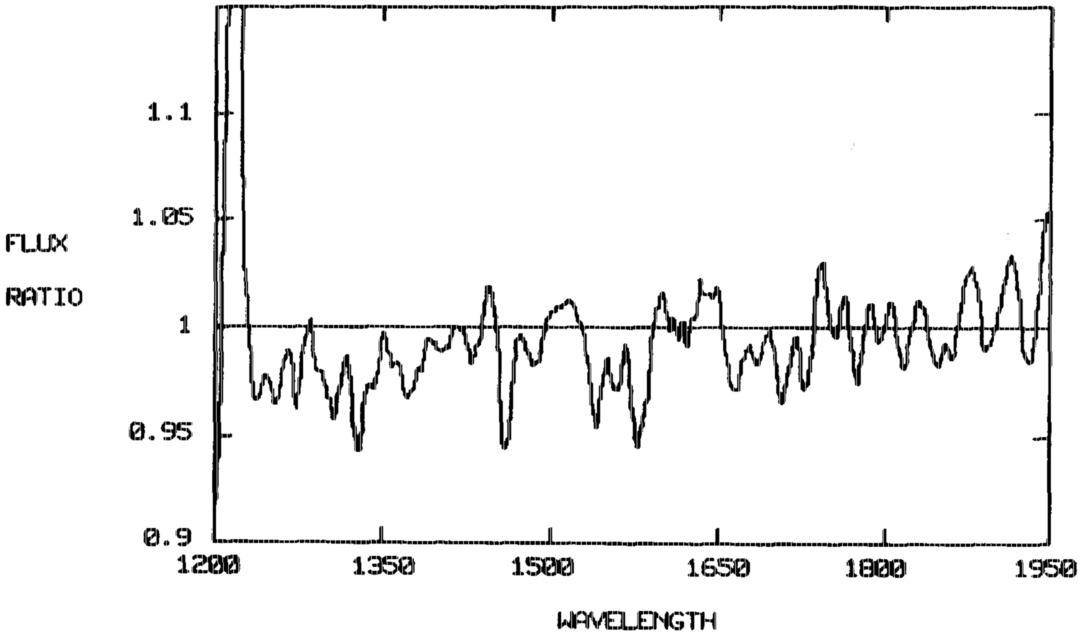
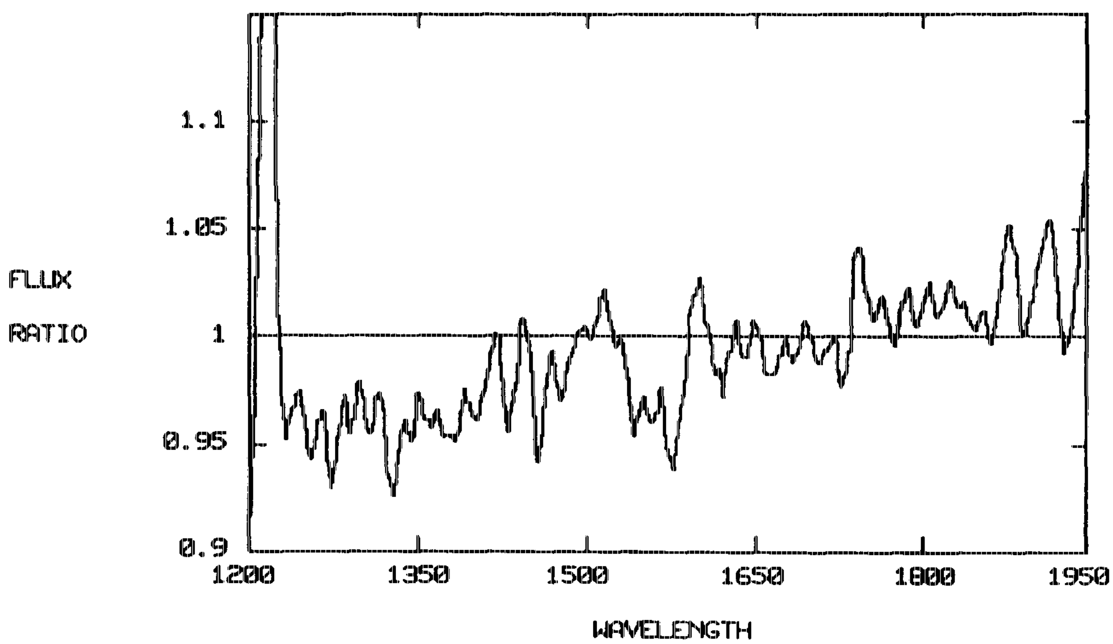


Figure 3c

100% (ITF3)/100% (ITF2)
SWP 25009 POINT SOURCE
DAY 29, 1985

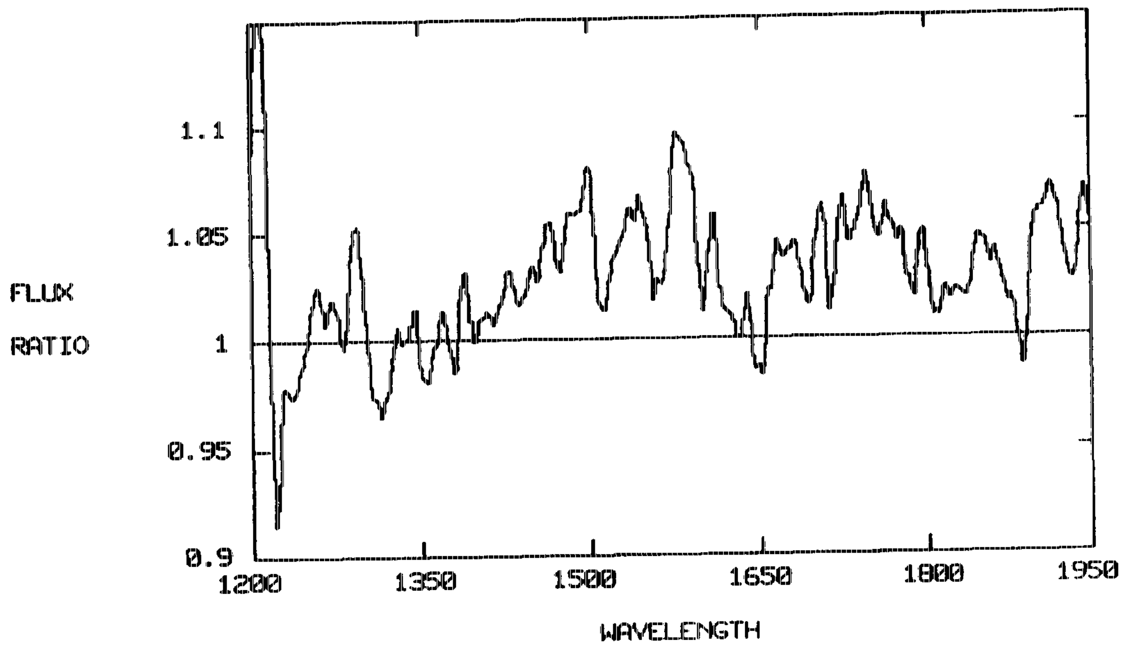


40%/100% TRAIL
SWP 25405/(SWP 25404 + SWP 25408)
DAY 68, 1985
NEW ITF

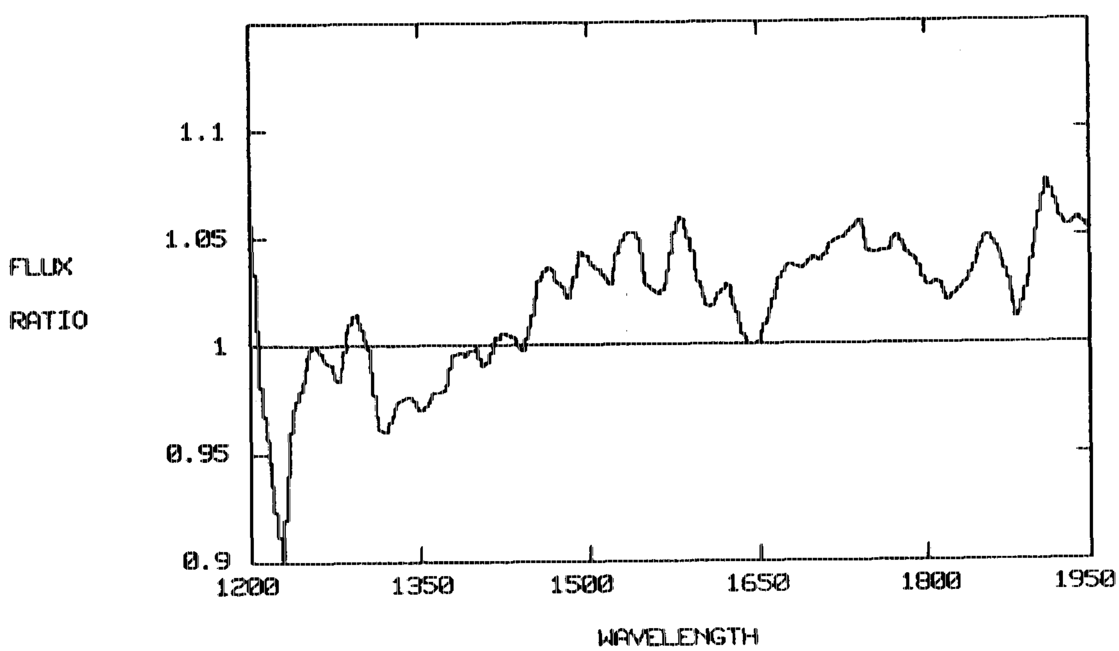


40%/100% TRAIL
SWP 25405/(SWP 25404 + SWP 25408)
DAY 68, 1985
OLD ITF

Figure 4a

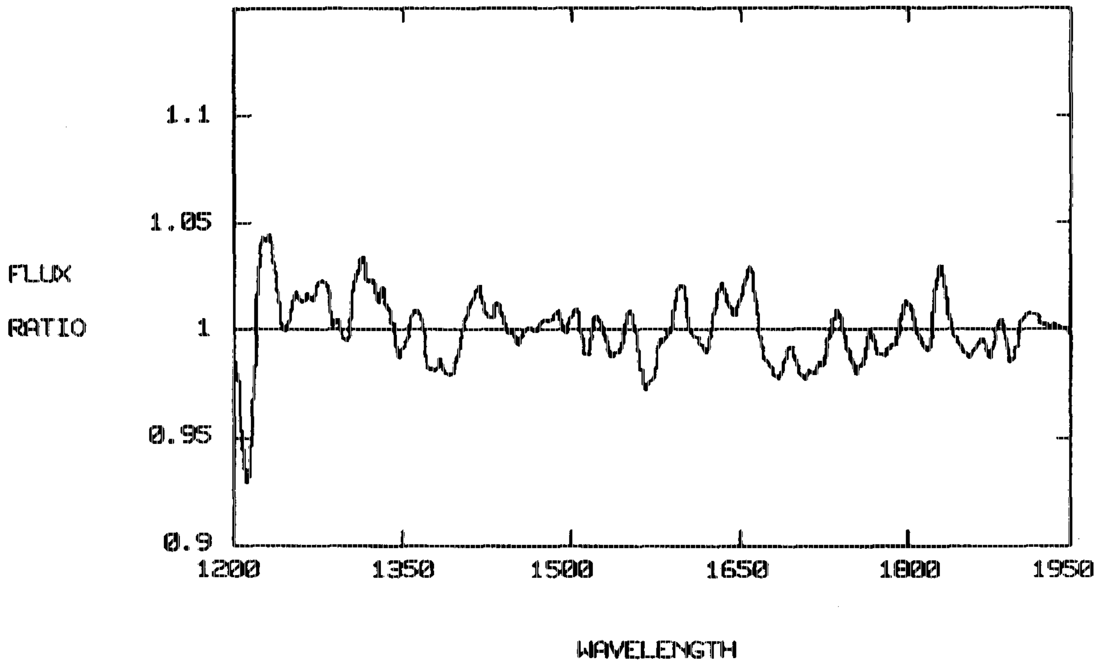


40%/100% TRAIL
SWP 3221/SWP 3219
DAY 309, 1978
NEW ITF

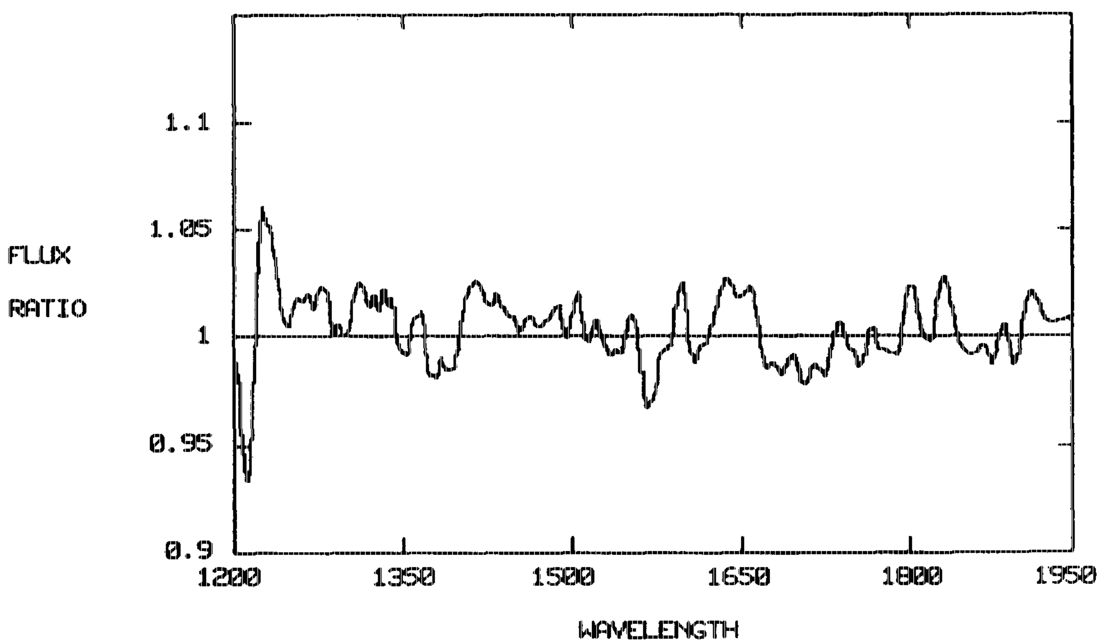


40%/100% TRAIL
SWP 3221/SWP 3219
DAY 309, 1978
OLD ITF

Figure 4b

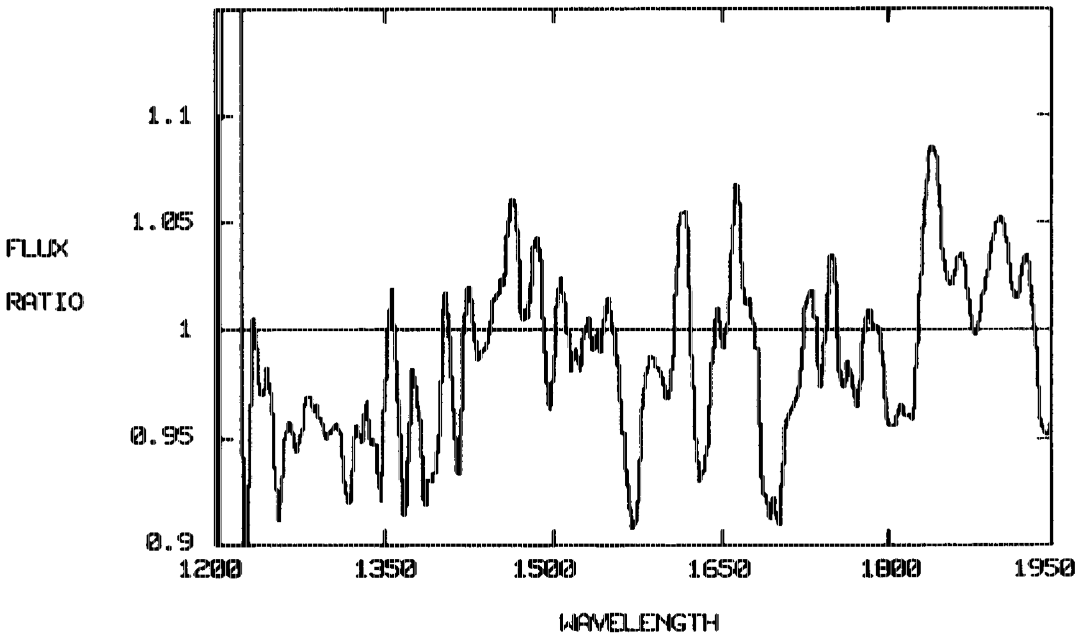


120%/100% TRAIL
SWP 25406/(SWP 25404 + SWP 25408)
DAY 68, 1985
NEW ITF

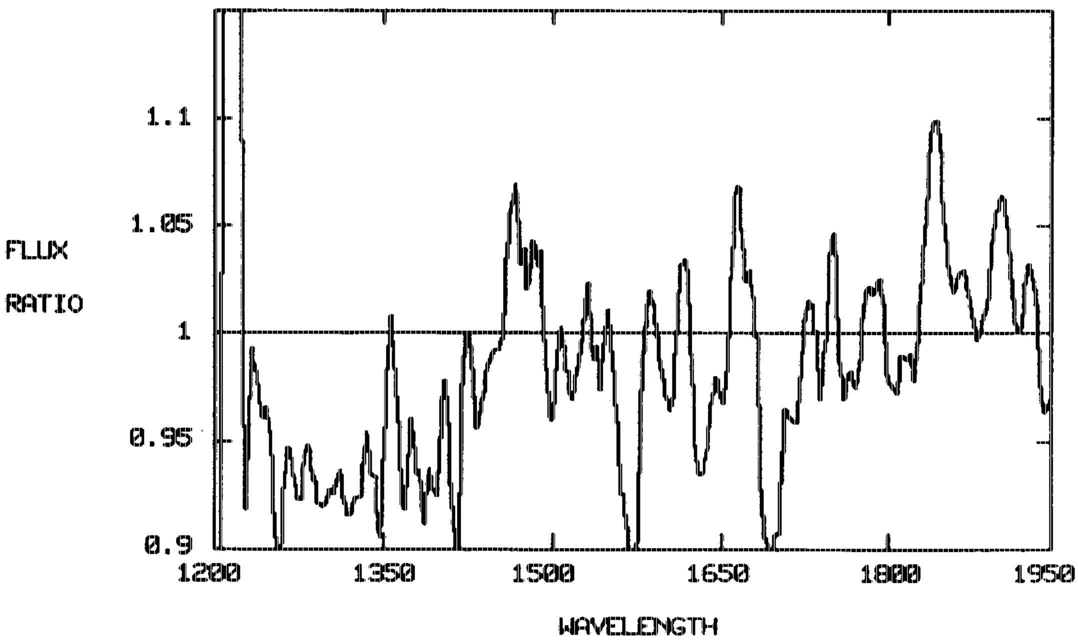


120%/100% TRAIL
SWP 25406/(SWP 25404 + SWP 25408)
DAY 68, 1985
OLD ITF

Figure 5

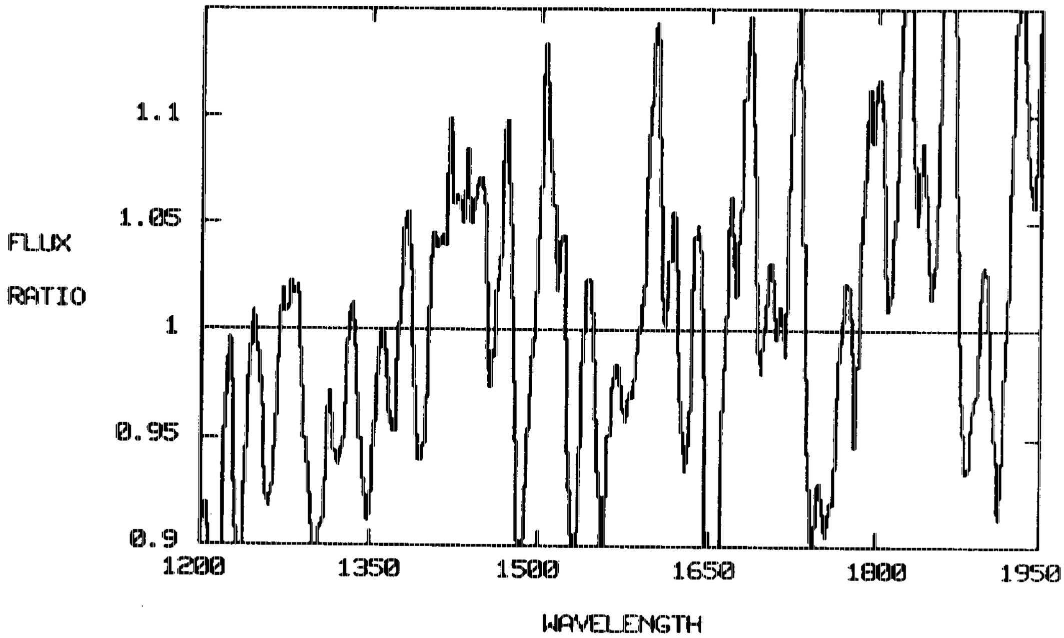


52%/100% POINT SOURCE
SWP 25007/SWP 25009
DAY 29, 1985
NEW ITF

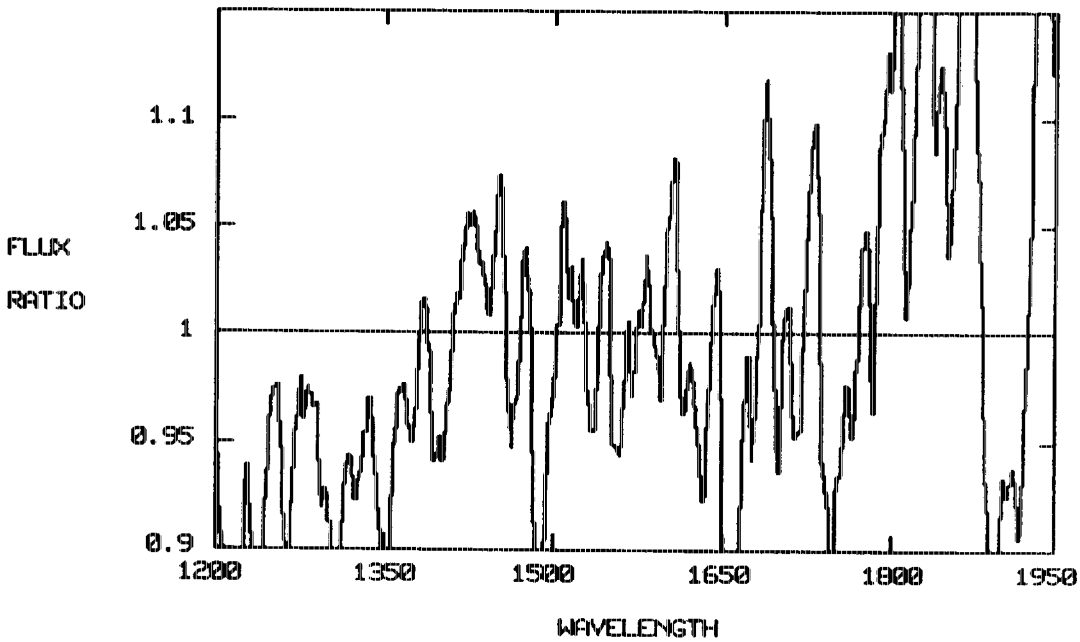


52%/100% POINT SOURCE
SWP 25007/SWP 25009
DAY 29, 1985
OLD ITF

Figure 6a

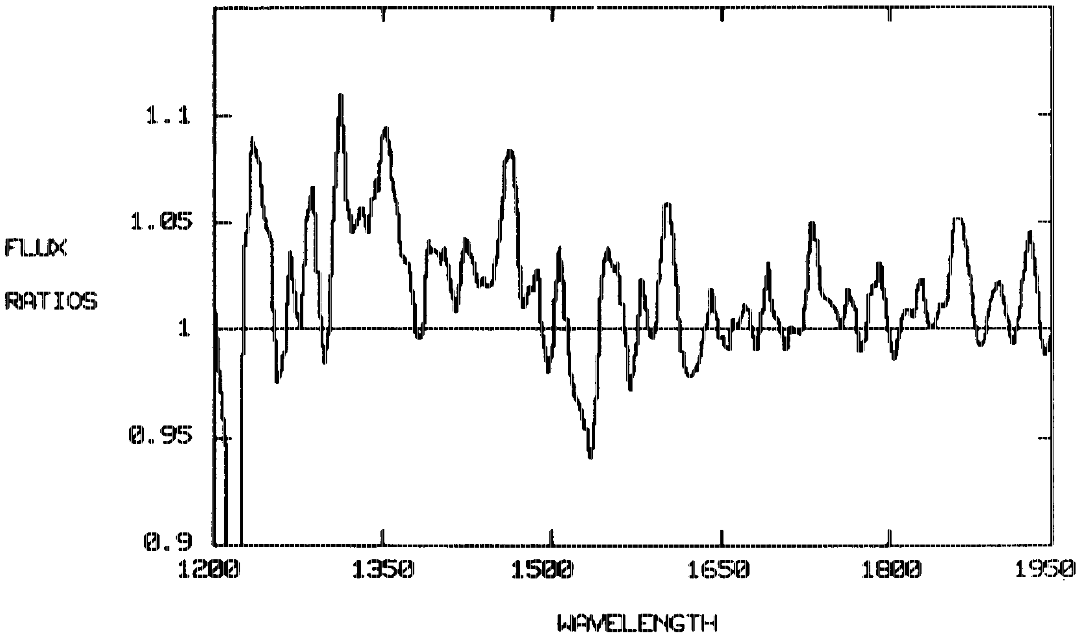


58%/100% POINT SOURCE
SWP 2445/SWP 2448
DAY 245, 1978
NEW ITF

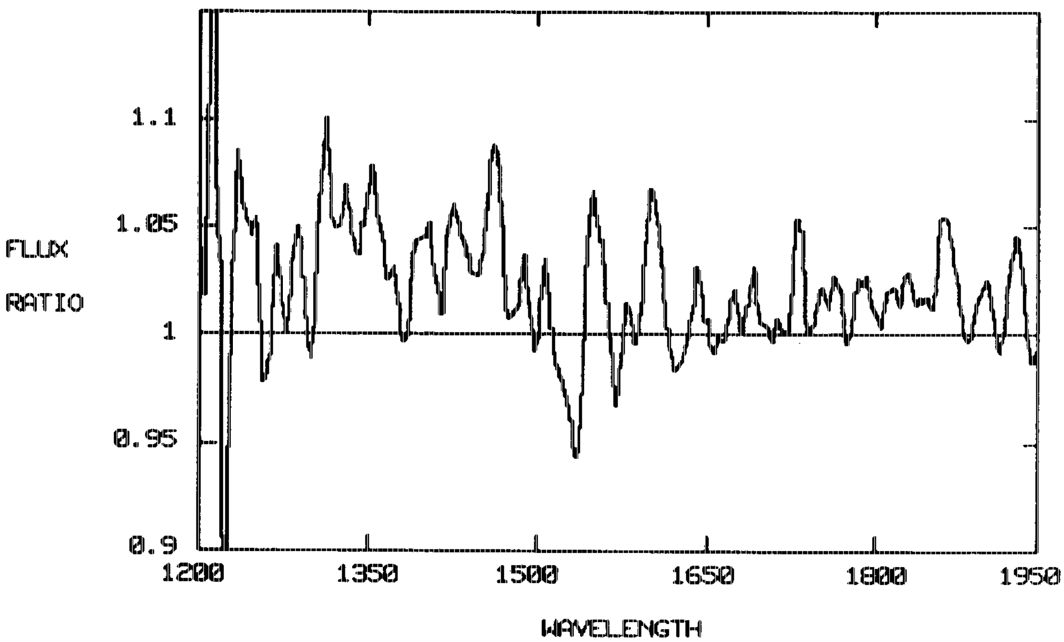


58%/100% POINT SOURCE
SWP 2445/SWP 2448
DAY 245, 1978
OLD ITF

Figure 6b

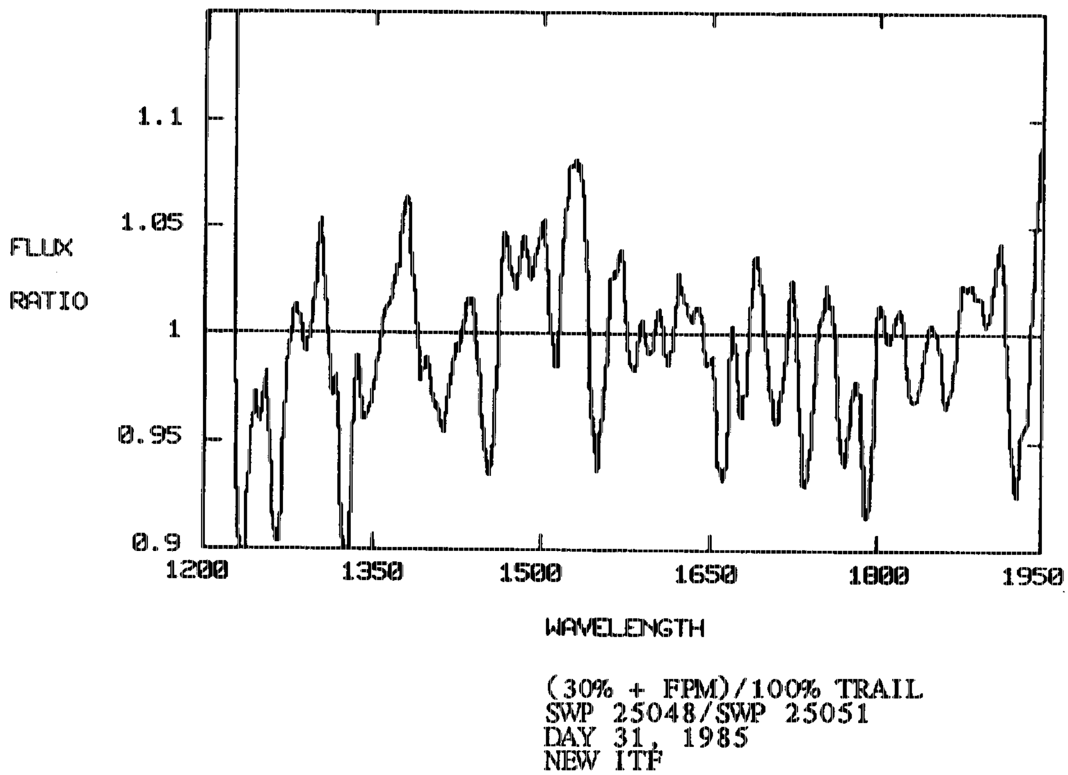


133%/100% POINT SOURCE
SWP 25010/SWP 25009
DAY 29, 1985
NEW ITF



133%/100% POINT SOURCE
SWP 25010/SWP 25009
DAY 29, 1985
OLD ITF

Figure 7


1.1
1.05
FLUX
RATIO
1
0.95
0.9
1200
1350
1500
1650
1800
1950
WAVELENGTH
(30% + FPM)/100% TRAIL
SWP 25048/SWP 25051
DAY 31, 1985
NEW ITF

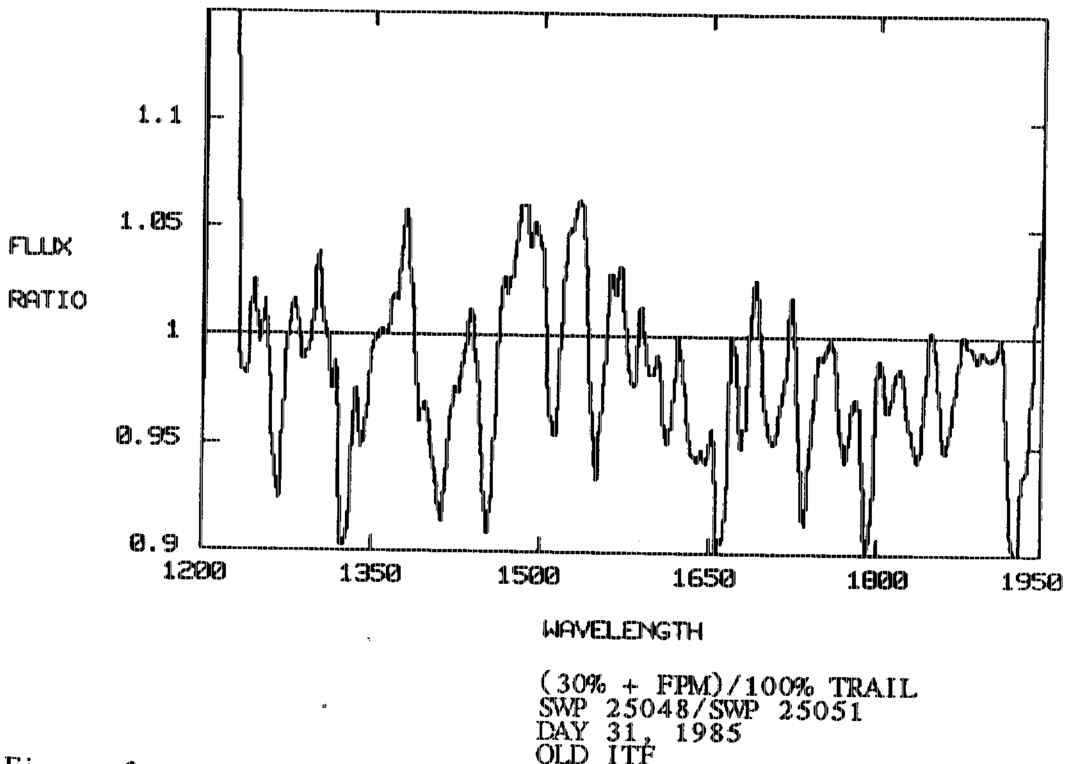
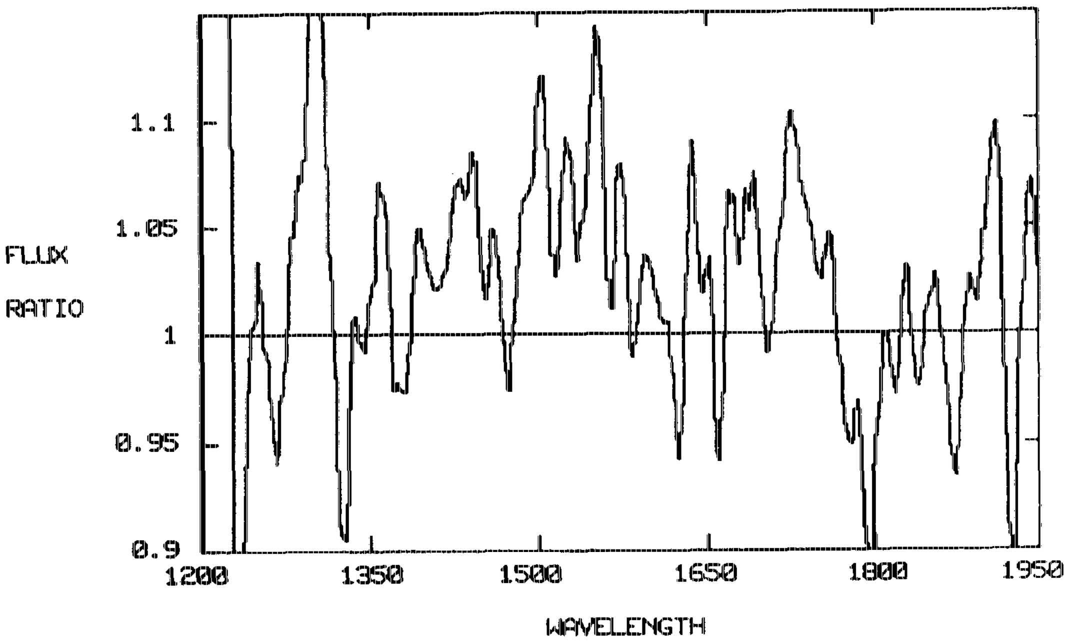
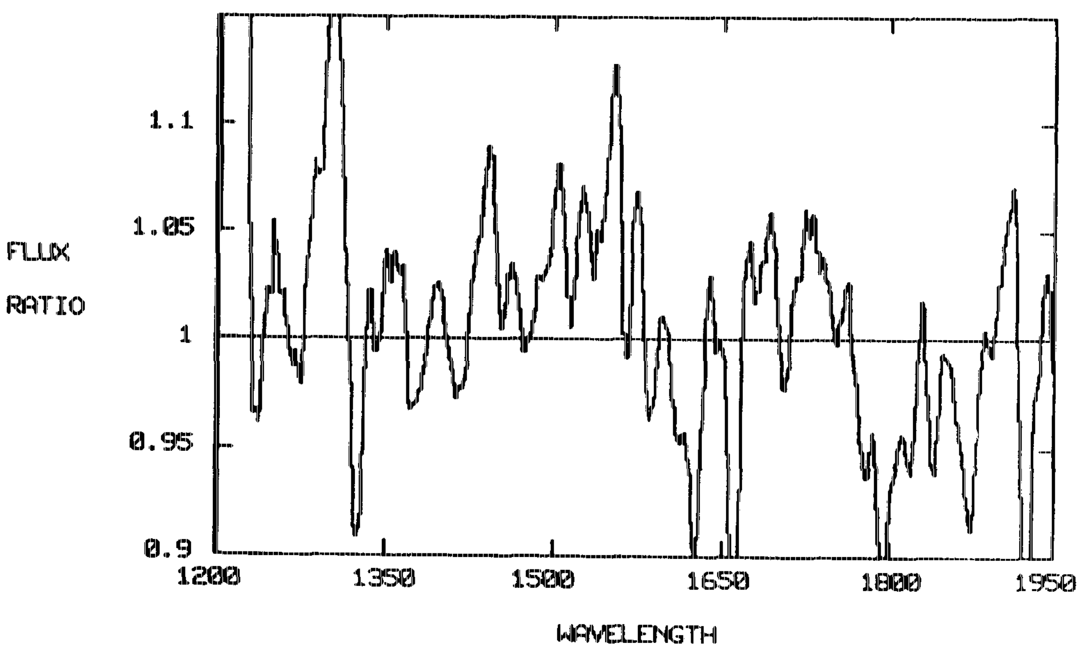

1.1
1.05
FLUX
RATIO
1
0.95
0.9
1200
1350
1500
1650
1800
1950
WAVELENGTH
(30% + FPM)/100% TRAIL
SWP 25048/SWP 25051
DAY 31, 1985
OLD ITF

Figure 8a



(27% + FPM)/100% TRAIL
SWP 25049/SWP 25051
DAY 31, 1985
NEW ITF



(27% + FPM)/100% TRAIL
SWP 25049/SWP 25051
DAY 31, 1985
OLD ITF

Figure 8b