PHOTOMETRIC CALIBRATION OF THE IUE

VIII. Comprehensive Revision to the IUE Absolute Calibration in Low Dispersion

A. History

As a result of the correction of the SWP ITF (Holm, Nov. 1979, NASA IUE Newsletter No. 7, 27), the absolute sensitivity of IUE in low dispersion has been reviewed. A premature summary of this review set a limit of 5% to the required changes in the SWP calibration (Bohlin, Holm, and Snijders, Feb. 1980, NASA IUE Newsletter No. 8, 38). After a comprehensive study of essentially all of the available calibration data for the first year of IUE operations, changes to the SWP calibration in the neighborhood of 10% are found. In addition to the SWP review, the available data on the LWR sensitivity were analyzed. Presented here are new inverse sensitivities for the first year of SWP and LWR spectra, as approved by the US/UK/ESA 3-agency project in May 1980. Small changes in sensitivity that may affect second year data from IUE are under study (Holm and Shiffer, April 1980, NASA IUE Newsletter No. 9, 8).

The need to revise the calibration was evident from a discontinuity between the flux distributions derived from the two cameras, as reported by several guest observers. A typical flux plot is shown in Fig. 1 using the original calibration and in Fig. 2 using the revised calibration presented here. Although the errors for both cameras are $\lesssim$ 10%, the systematic change was in opposite directions for the two cameras, making the discontinuity more pronounced.

B. Procedures

The basis for the absolute calibration remains unchanged and is the flux for η UMa as defined in Bohlin et al. 1980, A&A, in press or in preprint as NASA X-681-79-19. All measured fluxes for calibration stars were reduced to this common (or IUE) scale as before. The following items characterize the new calibration:

1. Point source spectra taken in the large aperture were used to set the absolute level of the calibration. Only those exposures free of any possible truncation by the ITF were chosen.

2. Trailed spectra, small aperture spectra, and aperture select shuttered spectra were used to improve signal-to-noise, to fill in the gaps created by reseaux, and to define the shape of the calibration. The exposure times for these spectra were assumed to be unknown.

3. Incorrectly processed SWP spectra were corrected using the 3 Agency algorithm (Cassatella et al., Feb. 1980, NASA IUE Newsletter No. 8, 1). Application of this algorithm may result in error of as much as 5% over wavelength regions of 50 to 100 Å (Holm and Schiffer, Feb. 1980, NASA IUE Newsletter No. 8, 45). While these correction errors are reduced to less than 1% when considering averages over an 800 Å bandpass, there is some evidence the small scale errors repeat for all the spectra of a given standard star. If it is assumed that the errors for each of the standard stars are independent, then the error in the algorithm that could propagate to the final values of S^{-1} should be < 1.6% ($=5\%/\sqrt{10}$ stars).

4. All wavelength assignments were corrected to the mean dispersion constants (Turnrose, Bohlin, and Harvel, Nov. 1979, NASA IUE Newsletter, 17) using the correction procedure of Harvel, Turnrose, and Bohlin (July 1979, NASA IUE Newsletter No. 5).

5. All spectra were corrected to the mean camera head temperatures of 8°C for SWP and 12°C for LWR by assuming the change in sensitivity with temperature to be -0.8%°C.

6. Essentially all of the first year calibration data was examined including 178 spectra of 7 TD-1 standard stars and 39 spectra of 7 OAO-2 standard stars.

The most significant improvement in the calibration is the result of point 6 above, i.e. the greatly expanded data base of standard star spectra. The mistake that was made in the Feb. 1980 report of < 5% change in the SWP calibration was the use of trailed spectra to set the absolute level of the calibration. We now realize that quoted trailed exposure times are systematically low by 5 to 10%.

C. Results

In the region of 1375 to 2540 Å covered by the large number of TD-1 spectra, the internal scatter in the determination of S^{-1} by individual stars is typically ± 3%. Longward of 3200 Å where the IUE has a low signal and only 16 total useful OAO-2 calibration spectra, the internal scatter exceeds 10%. Shortward of 1250 Å the derivation is complicated by the presence of strong absorption lines (HI λ1216, SiIII λ1206, and CIII λ1176), a reseau at 1192 Å, a rapid decline in sensitivity, and few calibration spectra. The adopted technique was to apply a preliminary version of the calibration to the IUE data, to integrate the IUE fluxes for individual samples through the OAO-2 point spread function, and to apply a correction to the calibration based on the mean ratios between the OAO-2 fluxes and the degraded IUE fluxes. This technique appears to be acceptable except at 1225 Å, where a combination of OAO-2 wavelength errors and OAO-2 point spread function errors cause an inaccurate result. Therefore, the 1225 Å value is an interpolation between 1200 Å and 1250 Å. The uncertain values of S^{-1} are flagged with colons in Tables 1 and 2. Except for these uncertain regions, the change is S^{-1} as given by the column headed by "Corr" in Tables 1 and 2 are nearly grey. The mean of the well determined correction factors are 1.093 ± 0.016 and 0.937 ± 0.022 for SWP and LWR, respectively. The main reason for the 9.3% change in SWP is the correction of the ITF error, while the 6.3% change in LWR is due to the expanded data base and improved techniques. Figures 3 and 4 are a graphical comparison of the old and new calibrations.

D. Policy

To avoid ambiguity in published IUE fluxes authors of papers in which fluxes are derived with the use of revised S^{-1} presented in this report are urged to state that the May 1980 calibration was used.

The low dispersion calibration used in production of G.O. tapes and plots will not be changed at this time because of the imminent change of software for production processing in low dispersion. It is possible that the absolute calibration may be different when the photometric correction is done first, as in the new software. New inverse sensitivities will be derived and implemented as required at that time.

Ralph Bohlin Albert Holm May 1980

TABLE 1

SWP Re-Calibration

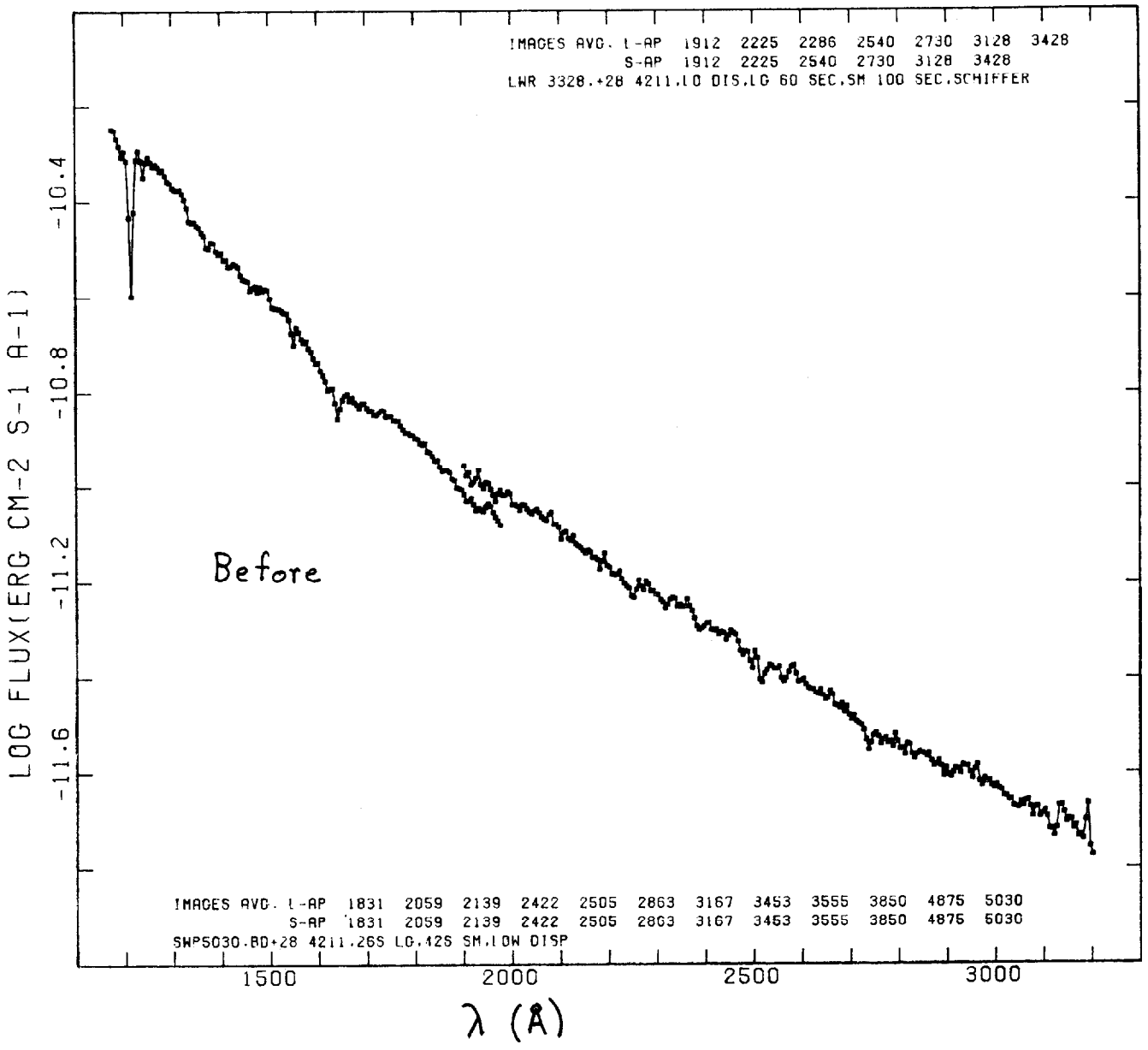
λ(Å)	S^{-1} (Original) (10^{-14} erg cm^{-2} Å^{-1} FN^{-1})	Corr.	S^{-1} (New) (10^{-14} erg cm^{-2} Å^{-1} FN^{-1})
1150	20:	1.035	20.7:
1175	6.65	1.191	7.92:
1200	3.65	1.189	4.34:
1225	2.68	1.089	2.92:
1250	2.23	1.081	2.41
1275	2.06	1.087	2.24
1300	2.02	1.079	2.18
1325	2.03	1.079	2.19
1350	2.07	1.092	2.26
1375	2.19	1.096	2.40
1400	2.36	1.102	2.60
1425	2.56	1.094	2.80
1450	2.75	1.105	3.04
1475	2.97	1.111	3.30
1500	3.19	1.110	3.54
1525	3.33	1.123	3.74
1550	3.43	1.120	3.84
1575	3.31	1.118	3.70
1600	3.16	1.108	3.50
1625	3.00	1.107	3.32
1650	2.85	1.095	3.12
1675	2.70	1.081	2.92
1700	2.53	1.079	2.73
1725	2.39	1.063	2.54
1750	2.22	1.063	2.36
1775	2.05	1.073	2.20
1800	1.97	1.066	2.10
1825	1.91	1.079	2.06
1850	1.87	1.091	2.04
1875	1.85	1.103	2.04
1900	1.84	1.103	2.03
1925	1.84	1.098	2.02
1950	1.84	1.098	2.02
1975	1.83	1.093	2.00

TABLE 2

LWR Re-Calibration

λ(Å)	S^{-1} (Original) (10^{-14} erg cm^{-2} Å^{-1} FN^{-1})	Corr.	S^{-1} (New) (10^{-14} erg cm^{-2} Å^{-1} FN^{-1})
1850	*15.0:	.960	14.4:
1900	*5.2	.942	4.90
1950	3.0	.931	2.79
2000	2.04	.921	1.88
2050	1.77	.916	1.62
2100	1.65	.912	1.50
2150	1.61	.911	1.47
2200	1.54	.911	1.40
2250	1.32	.912	1.20
2300	1.10	.912	1.00
2350	.90	.913	.822
2400	.76	.915	.695
2450	.63	.923	.581
2500	.54	.932	.503
2550	.47	.947	.445
2600	.42	.957	.402
2650	.38	.962	.366
2700	.35	.969	.339
2750	.34	.971	.330
2800	.34	.969	.329
2850	.35	.967	.338
2900	.38	.963	.366
2950	.43	.957	.412
3000	.51	.949	.484
3050	.64	.944	.604
3100	.91	.935	.851
3150	1.4:	.924	1.29
3200	2.3:	.915	2.10:
3250	4.2:	.908	3.81:
3300	8.9:	.900	8.01:
3350	19.:	.89	16.9:

*Changed Nov. 1979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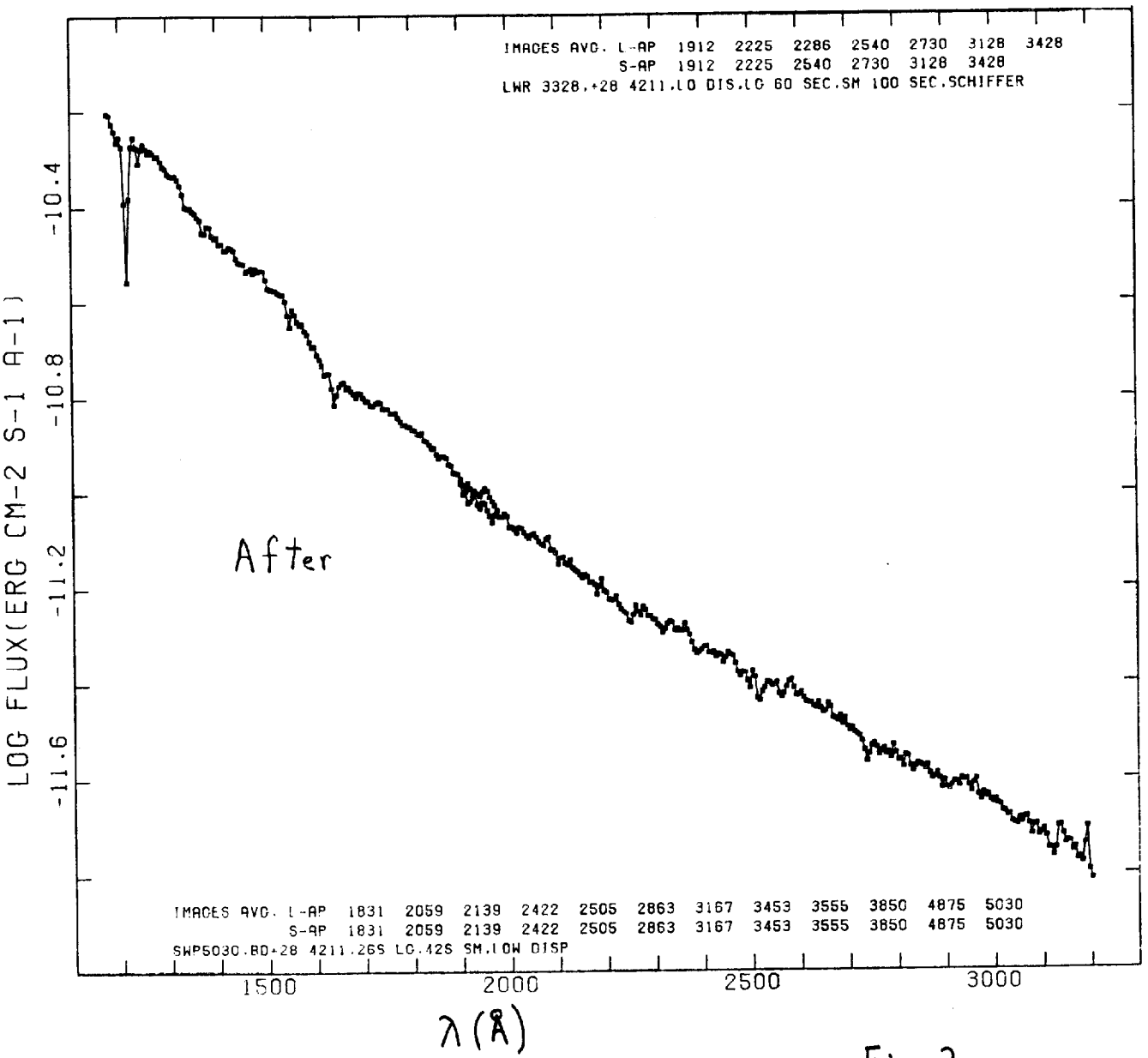
S-AP 1912 2225 2540 2730 3128 3428
LWR 3328.+28 4211.10 DIS.LG 60 SEC.SM 100 SEC.SCHIFFER
Before
IMAGES AVG. L-AP 1831 2059 2139 2422 2505 2863 3167 3453 3555 3850 4875 5030
S-AP 1831 2059 2139 2422 2505 2863 3167 3453 3555 3850 4875 5030
SWP5030.BD+28 4211.26S LG.42S SM.LOW DISP
LOG FLUX(ERG CM-2 S-1 A-1)
-10.4
-10.8
-11.2
-11.6
1500
2000
2500
3000
λ (Å)

Fig. 1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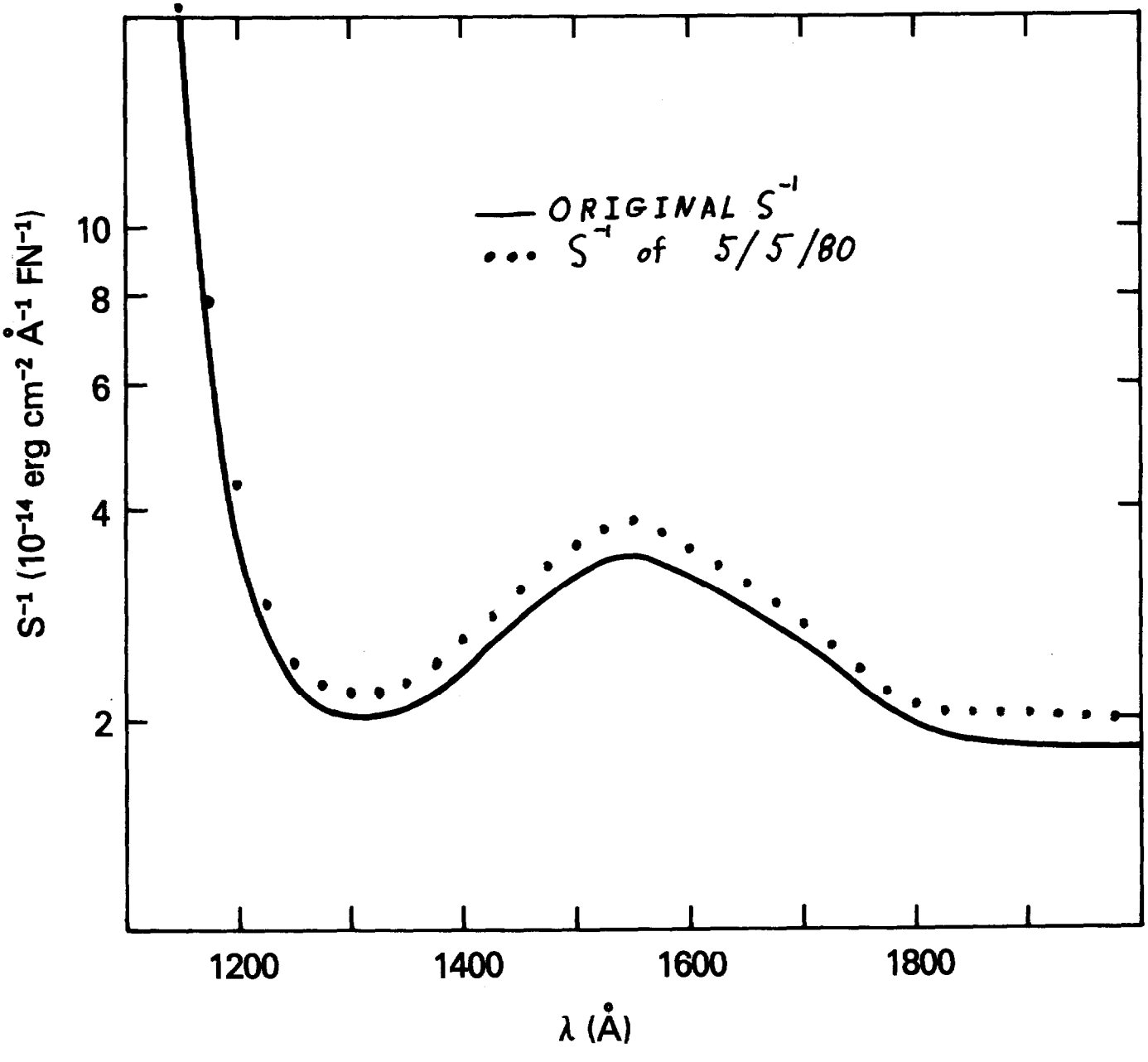
S-AP 1912 2225 2540 2730 3128 3428
LWR 3328,+28 4211.LO DIS.LO 60 SEC.SM 100 SEC.SCHIFFER
After
IMAGES AVG. L-AP 1831 2059 2139 2422 2505 2863 3167 3453 3555 3850 4875 5030
S-AP 1831 2059 2139 2422 2505 2863 3167 3453 3555 3850 4875 5030
SWP5030.BD+28 4211.26S LO.42S SM.LOW DISP
LOG FLUX(ERG CM-2 S-1 A-1)
-10.4
-10.8
-11.2
-11.6
1500
2000
2500
3000
λ(Å)

Fig. 2


ORIGINAL S⁻¹
S⁻¹ of 5/5/80
S⁻¹ (10⁻¹⁴ erg cm⁻² Å⁻¹ FN⁻¹)
10
8
6
4
2
1200
1400
1600
1800
λ (Å)

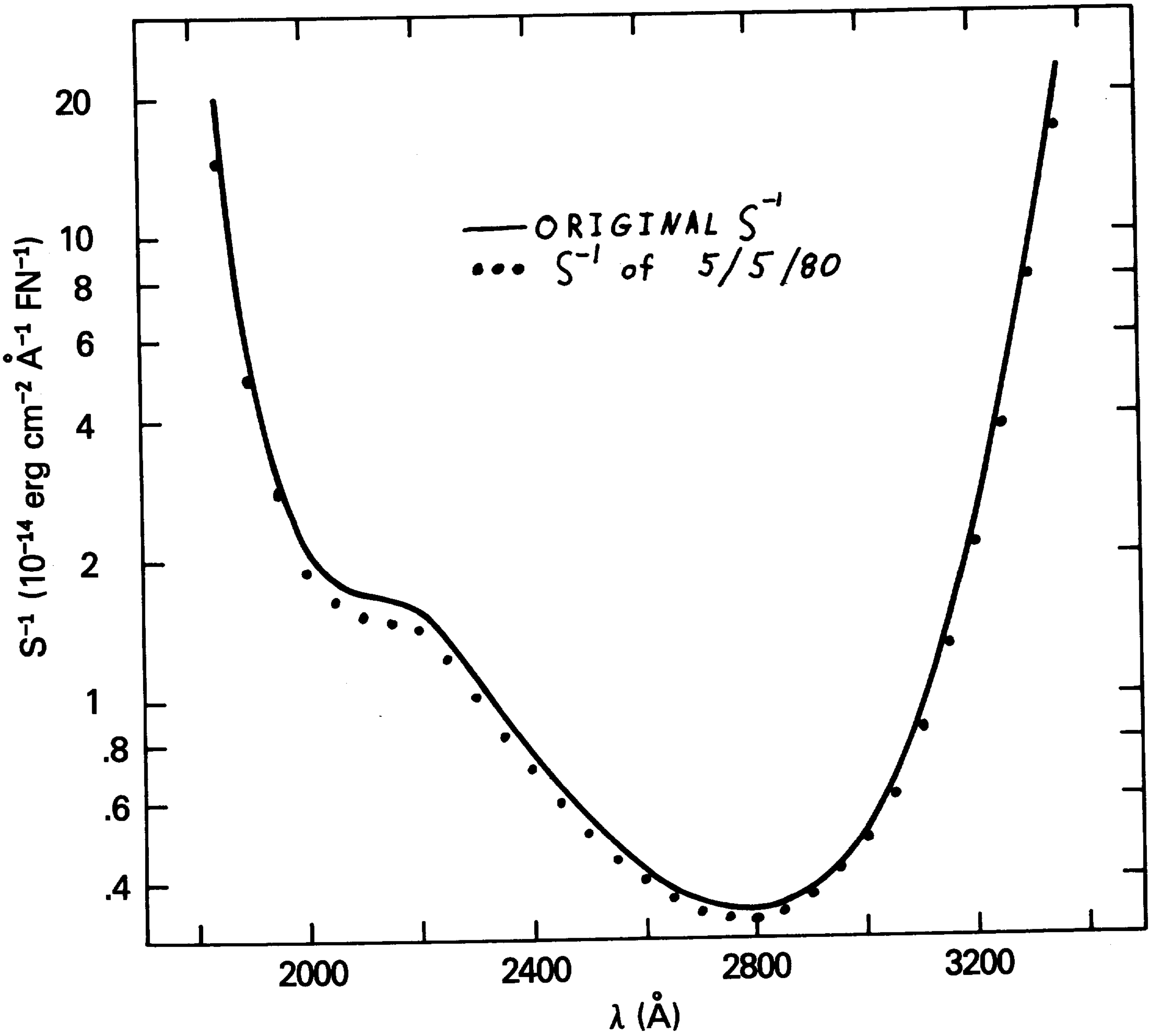

—ORIGINAL S^-1
••• S^-1 of 5/5/80
S^-1 (10^-14 erg cm^-2 Å^-1 FN^-1)
20
10
8
6
4
2
1
.8
.6
.4
2000
2400
2800
3200
λ (Å)

Fig. 4