The IUE Point-Spread Function in High Dispersion

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Abstract Line widths from a series of IUE high dispersion spectra have been measured to determine the point-spread function along the dispersion. Results for calibration lamp spectra for the LWP, LWR, and SWP cameras are presented. The widths are consistent with a resolution which is constant in pixels and thus probably determined by the camera. The new processing software results in a resolution which is somewhat improved in the long wavelength cameras, but unchanged for the SWP. The two long-wavelength cameras have similar resolution near the MgII lines.

Narrow interstellar absorption lines have been measured on a spectrum of Zeta Oph. Comparison with the line widths from Copernicus data shows that the point-spread function for a stellar spectrum is about the same as that from a platinum spectrum for the SWP camera.

I. Introduction

Part of the calibration effort of the IUE project has been to analyze the point-spread function of the spectra. The results for low dispersion have recently been summarized (Cassatella, et al., 1985). We present here results for high dispersion along the dispersion, from both the on-board calibration lamp and a stellar source. The results from the Pt-Ne calibration lamp are discussed in three parts: basic results for all three cameras, a comparison between old and new software processing, and a comparison between the LWP and the LWR cameras. In the final section the results for a stellar source are presented.

II. The Platinum Lamp Spectra

Three platinum lamp spectra acquired in high dispersion were used for the basic analysis: LWP 1616, LWR 13780, and SWP 20241. Each was obtained with 1/3 the usual exposure time employed for the standard wavelength calibration sequence in order to increase the number of unsaturated lines available. A fourth calibration spectrum (SWP 21649) with the standard exposure time was measured. This spectrum provided more well-exposed lines in higher orders for the SWP analysis. All spectra were processed with the new high-dispersion software (Turnrose, Thompson and Bohlin, 1982) which uses greater sampling frequency than the original processing.

For each spectrum, lines were chosen for analysis according to the following criteria. (1) The line is identified in the standard IUE line library. (2) The line is reasonably well exposed, including no extrapolated or saturated pixels. (3) The line does not appear to be blended. In practice, these criteria were relaxed somewhat in order to get adequate wavelength coverage for the spectra. Orders 72 through 123 (1870 - 3230 A) were searched for the long wavelength cameras. Orders 66 through 118 (1160 - 2086 A) were searched for the SWP.

For all the images, the net extracted spectra were taken from the MEHI file. The MEHI file includes no ripple correction and no noise filters. For the purpose of this analysis the standard optimal noise filters were applied to the data before measurements were made (Bohlin and Turnrose, 1982). No ripple correction was applied.

The platinum line widths were determined with the FEATURE procedure at the Goddard RDAF. This program computes a flux-weighted standard deviation, which was then converted to the FWHM (FWHM = 2.355 x s.d., for a Gaussian profile). For comparison, the lines were also fitted with the RDAF procedure GAUSSFIT, which fits a Gaussian to the line profile to determine the full width at half maximum. The two sets of measurements were entirely consistent; there was neither a systematic offset, nor a trend in the differences as a function of order number.

Because the LWP is less sensitive than the LWR at shorter wavelengths, fewer lines are optimally exposed. Thus the LWP line widths are not as accurate as those for the LWR at these wavelengths (roughly shortward of 2600 A). The lines at the extreme ends of the orders (about 10% on each end) are broadened by approximately 10% in the long wavelength cameras. This effect is less apparent in the SWP spectrum.

By simple inspection, the platinum lines appear to be symmetric in the SWP and LWR cameras. However, a small redward wing is seen in the LWP lines.

The data are plotted in Figures 1 through 3.

For the SWP camera, a second spectrum was used to increase the number of lines available at higher orders. SWP 21649 is a normal wavelength calibration exposure (2 minutes) while SWP 20241 is a 40 second exposure. Figure 3 shows that the data from SWP 21649 (diamonds) are consistent with those of SWP 20241 (pluses).

These results are consistent with the idea that the camera properties determine the resolution. The resolution in pixels remains constant; the smaller line widths in Angstroms in the higher orders are the result of the higher dispersion in these orders. However, we are assured by R. Wilson (private communication) that none of the components in IUE were over-designed, that the resolutions of all are well matched.

These results were compared to those obtained by Cassatella and Martin (1982) and Cassatella, Martin, and Ponz (1981), measured in a similar way from spectra reduced with the old processing (pre-1982, in which the sampling frequency was a factor of 2 less). The results are summarized in Table 1. The new processing software, with its higher sampling frequency, results in somewhat improved spectral resolution in the long-wavelength cameras. However, little change is apparent in the resolution for the SWP.

Figure 4 shows the results of Figures 1 and 2 overplotted to compare the resolutions of the two long-wavelength cameras. The resolution of the LWR is somewhat better that that of the LWP at long wavelengths, about the same around the MgII lines, and not as good at shorter wavelengths.

III. Stellar Spectra

In order to measure the point spread function from a stellar source, line widths of interstellar lines in a spectrum of Zeta Oph (SWP 17584) were measured. The initial investigation was made by comparing the measured line widths with the equivalent widths from Copernicus observations (Morton, 1975). Unfortunately, only lines 50 mA or stronger can be measured on IUE spectra with a reasonable signal to noise ratio. As a result, all lines have appreciable intrinsic widening. As an example from the Copernicus data (Rogerson, et al., 1973), the line C I 1280.135 has an equivalent width of 34 mA, a measured FWHM of 0.06 A (for the U1 system) and an intrinsic width of 0.03 A.

The original analysis showed a correlation between the IUE FWHM and the Copernicus equivalent widths. The analysis was made more direct when E. Jenkins kindly supplied copies of Copernicus profiles for 10 lines from which the FWHM could be measured directly. The results are listed in Table 2 and plotted in Figure 5. These lines are all found in orders greater than 100. The correlation between the IUE and Copernicus line widths is apparent in Figure 5. The lower line represents a one-to-one correlation between the widths for Copernicus and IUE profiles. The upper line shows the relationship between Copernicus and IUE line widths on the assumption that the IUE FWHM is 0.09 A in this wavelength region (as found from platinum spectra) and the Copernicus FWHM is 0.05 A; that is:

$$FWHM_{obs}^2 = FWHM_{line}^2 + FWHM_{inst}^2$$

where $FWHM_{obs}$, $FWHM_{line}$, and $FWHM_{inst}$ are the full widths at half maximum of the observed profile, the intrinsic line, and the instrument (IUE or Copernicus) respectively. The second line fits the data well. Thus the point-spread function for IUE stellar specta matches well that for the platinum spectra; there is no evidence for extra broadening in the stellar spectrum.

Bibliography

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Table 1: Typical Platinum Line Widths (FWHM)
for Old and New Processing Software

Order	Wavelength	LWR(old)	LWR(new)	LWP(new)
75	3100 A	.24 A	.19 A	.22 A
83	2800	.21	.17	.17
96	2400	.18	.16	.13
116	2000	.17	.15	.125

Order	Wavelength	SWP(old)	SWP(new)
69	2000 A	.19 A	.19 A
76	1800	.17	.16
86	1600	.13	.12
106	1300	.10	.09

Table 2

Interstellar Line Widths (FWHM) in Angstroms of Zeta Oph

		Copernicus	IUE	
CII	1335.703	0.131	0.146	
CI	1329.101	0.058	0.106	
CI	1328.833	0.070	0.127	
SiIII	1304.372	0.127	0.108	
CI	1277.245	0.078	0.085	
SiIII-FeII	1260.421	0.164	0.170	blended
SII	1259.520	0.111	0.132	
SII	1253.812	0.111	0.115	
SII	1250.586	0.105	0.144	
NI	1200.224	0.129	0.129	noisy

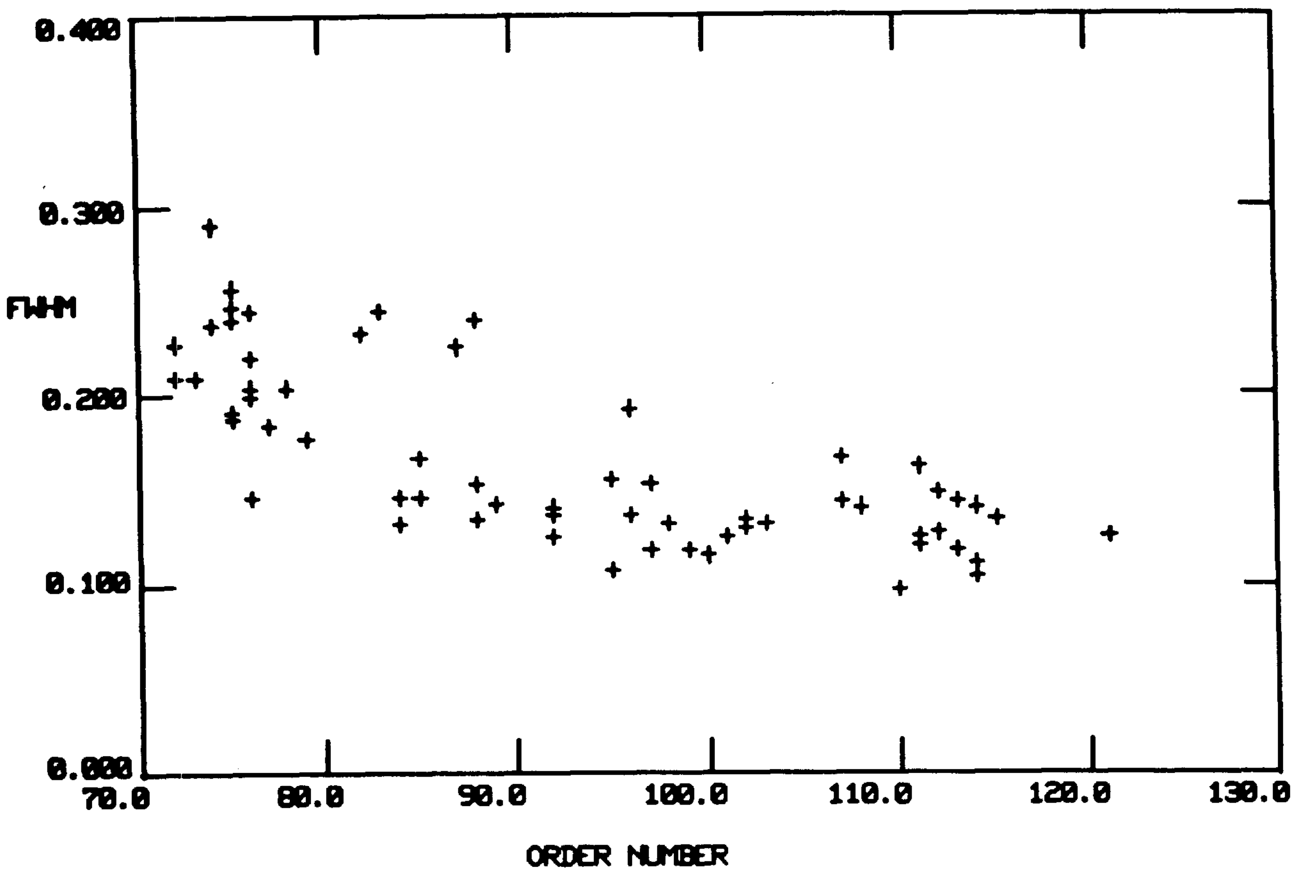

Figure 1. FWHM in Angstroms for platinum lines along the dispersion in the LWP camera.

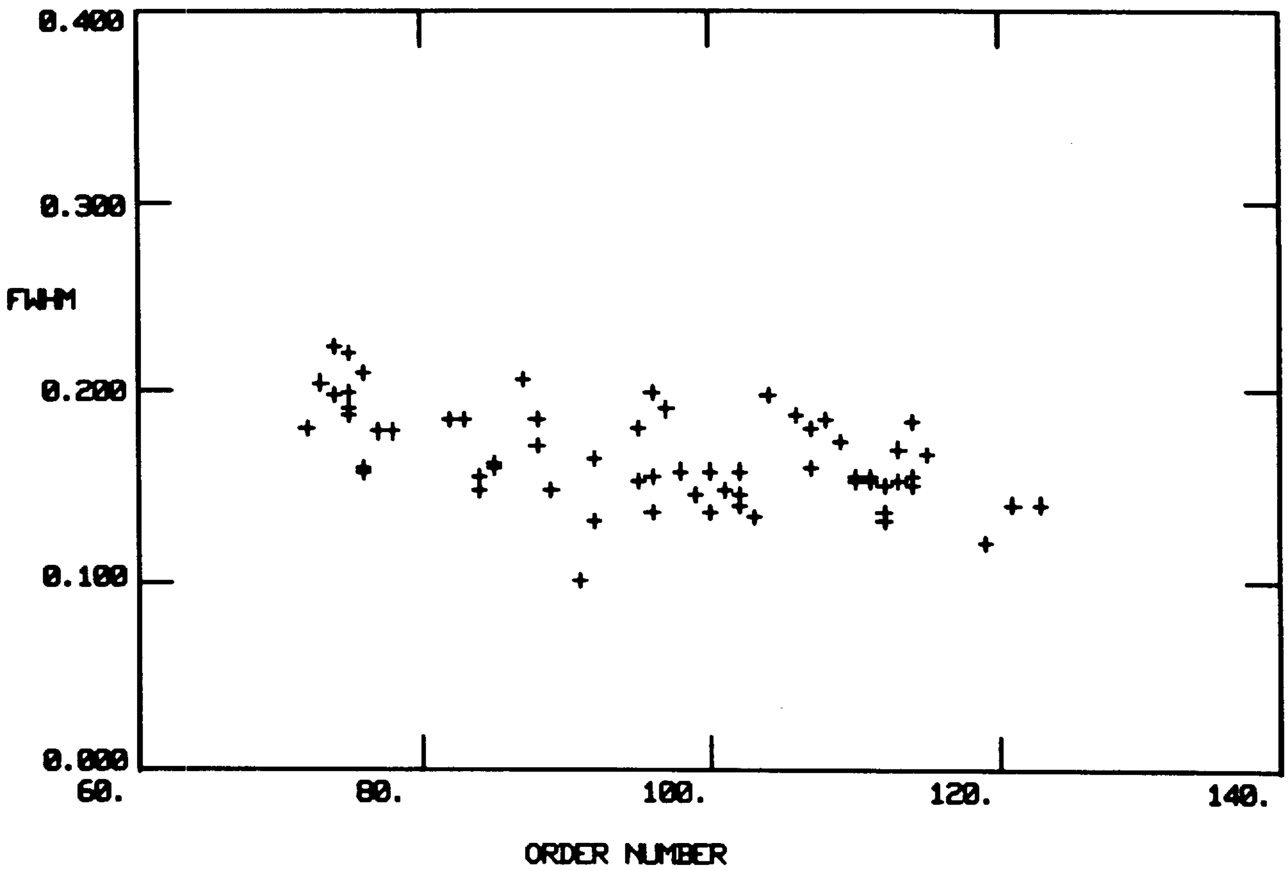

Figure 2. FWHM in Angstroms for platinum lines along the disperison in the LWR camera.

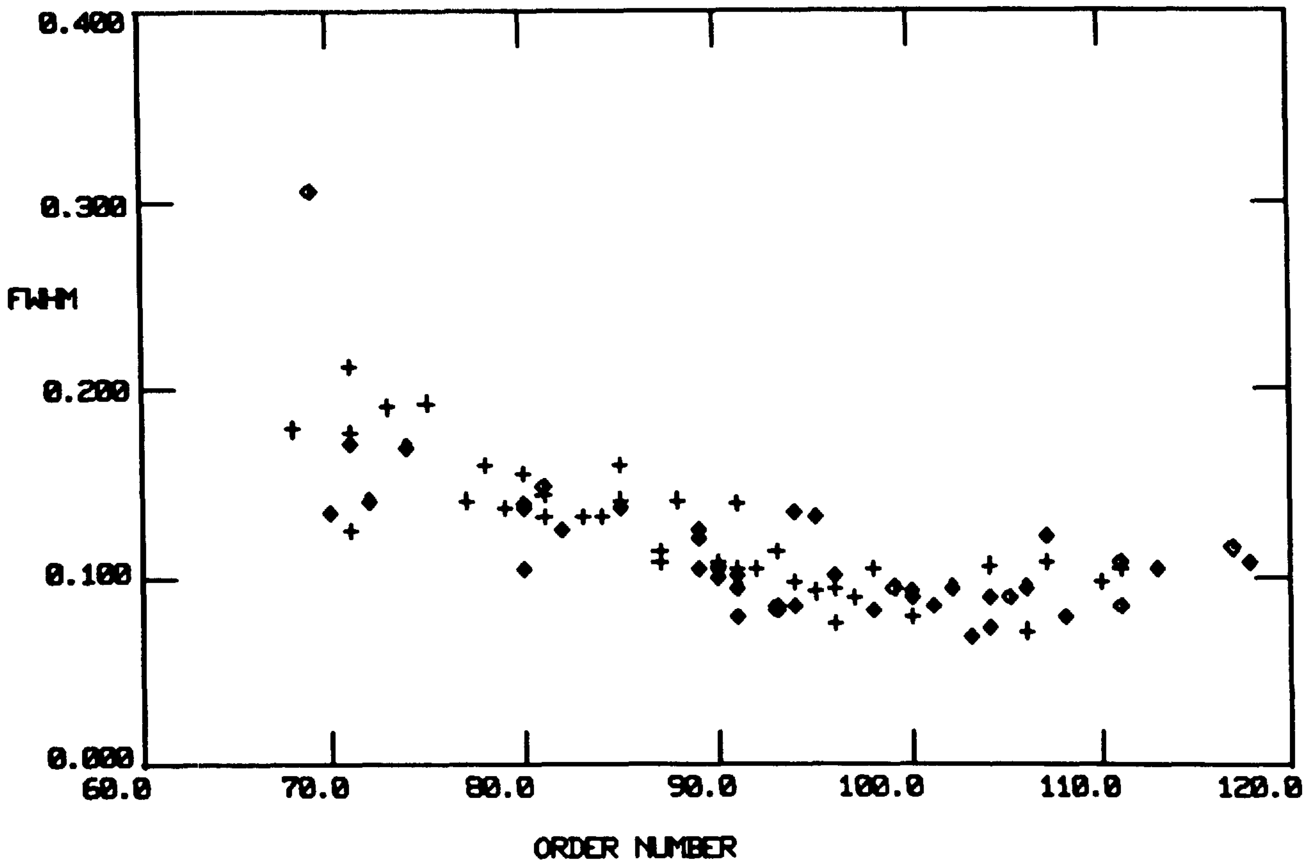

Figure 3. FWHM in Angstroms for platinum lines along the dispersion in the SWP camera. Pluses are from SWP 20241; diamonds are from SWP 21649.

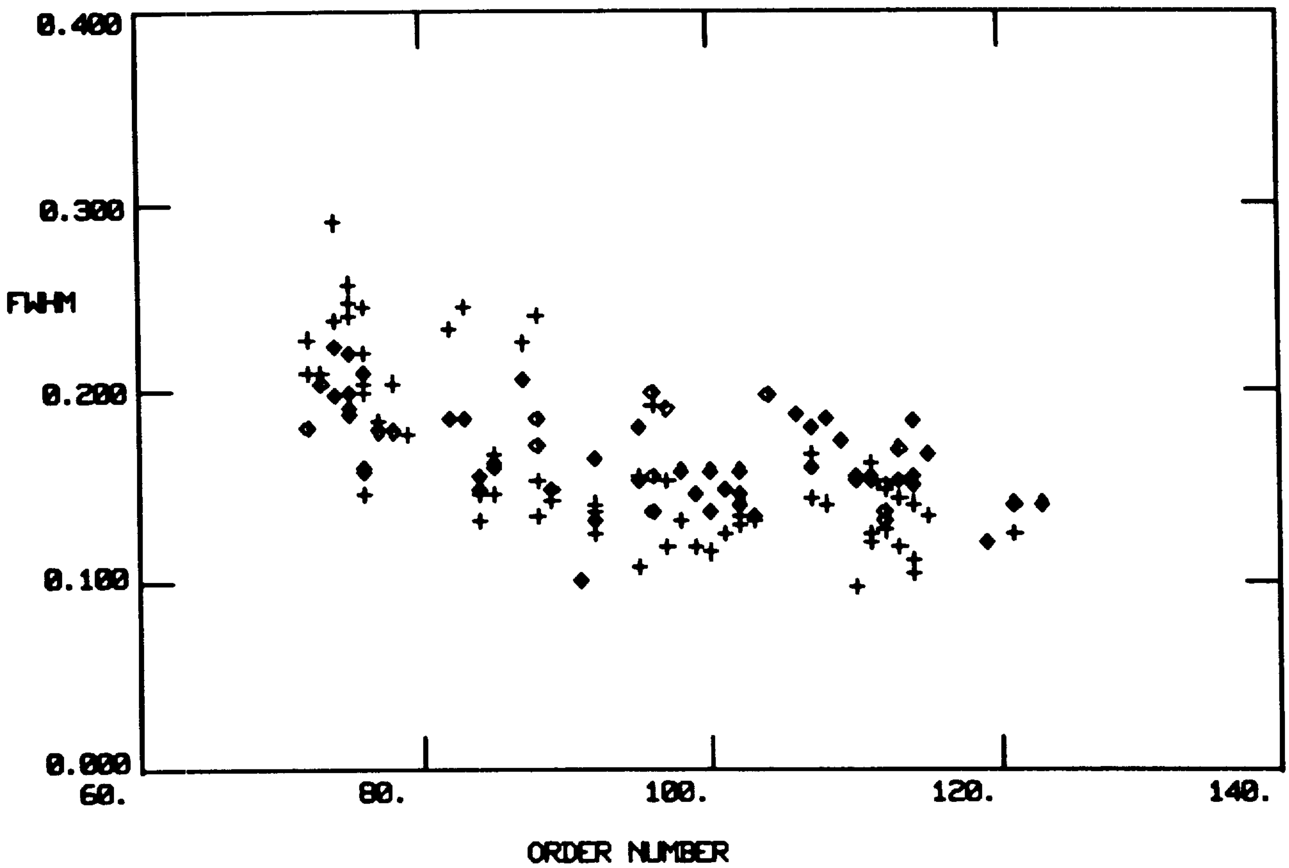

Figure 4. FWHM in Angstroms for platinum lines along the disperison; diamonds: LWR; pluses: LWP.

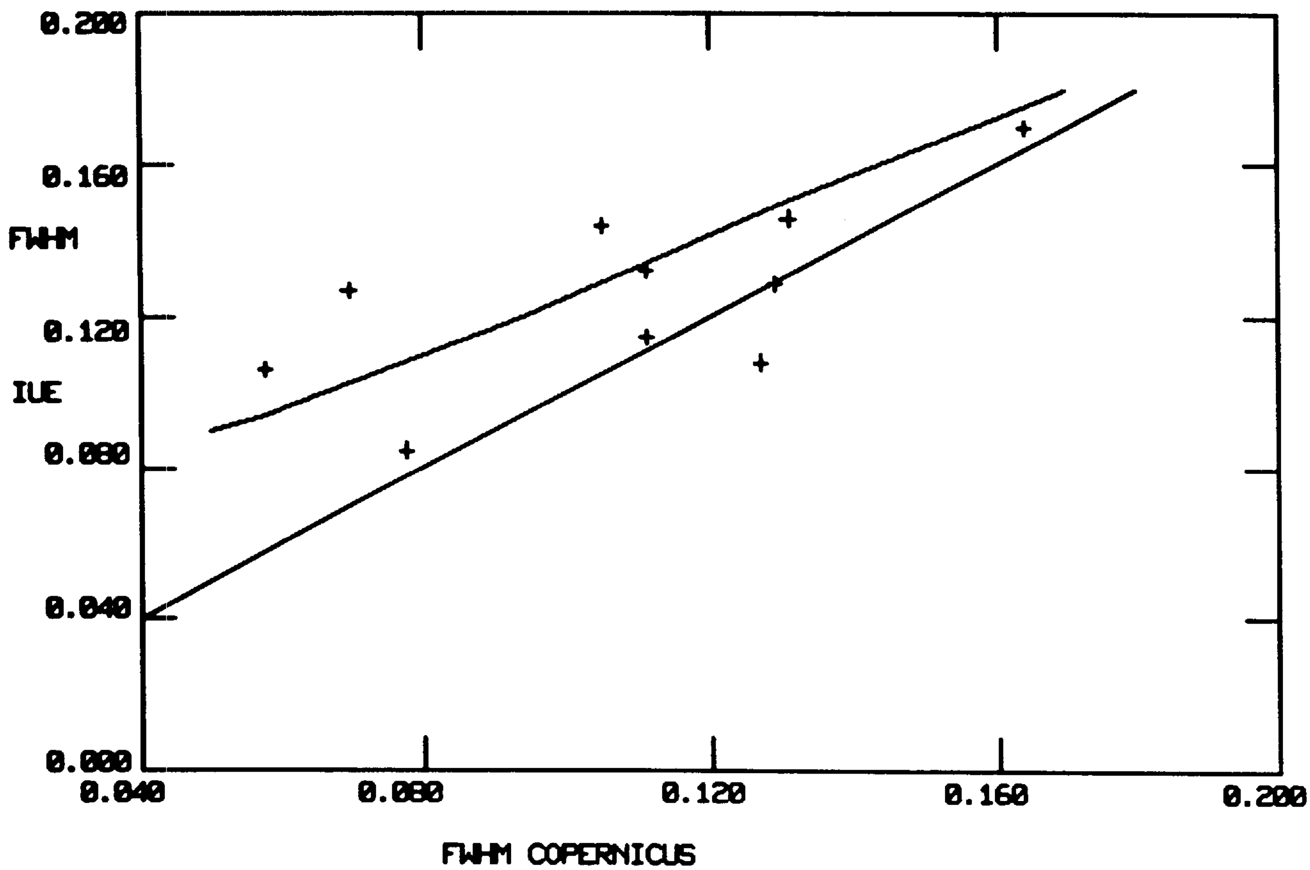

Figure 5. Comparison of FWHM in Angstroms for IUE and Copernicus. The lower line is FWHM (IUE) = FWHM (Copernicus). The upper line is predicted assuming FWHM (IUE) = 0.09 A and FWHM (Copernicus) = 0.05 A.