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SPACE TELESCOPE SCIENCE INSTITUTE

INSTRUMENT SCIENCE REPORT
CAL/FOS-007

TITLE: FOS Scattered Light Measurements

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The scattered light measurements in the dispersion direction are reported incorrectly in the memo of 11/7/83. Table 1 of this report replaces Table 2 in the previous memo. A corrected report follows.

Line profiles of two isolated spectral lines emitted by a 60 Hz Mercury lamp were obtained on 29 October 1983. Each line was isolated with a narrow-band filter. Because the wings of the spectral line are too faint to be captured on an unsaturated exposure of the peak, a 25s exposure with the 1".0 circular aperture was made for the wings, and a 1s exposure with the 0".1 aperture captured the peak. The peak count rate in the 2536.5 Å line is 24,000 cts/s. However, because the lamp output is pulsed, the count rate during the lamp's on-cycle may be much higher, requiring a substantial correction for the detector non-linearity. Examination of two exposures made at different lamp brightnesses suggests that the true peak count rate in the 2536Å exposure is approximately 50,000 cts/s with the 0".1 aperture. The 4358.3Å line, on the other hand, has a peak count rate of 3800 cts/s, for which the above effect is less than 5%. To

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determine the light intensity in the wings relative to the peak, one must take into account the relative sizes of the apertures and the different exposure times. We are interested in the amount of scattered light relative to the total light in the integrated profile, and this is proportional to the area of the aperture used for the exposure. If we use the microscope measurements of the apertures, the ratio between the 1.0 aresec and the 0.1 arcsec aperture is $\frac{.981}{.0091} = 108.$

The scattered light measured at various distances from the line center is compared with the specifications in Table 1. The figures for the 2536Å line show the uncorrected count rate in the line peak. When corrected by a factor of 2, the observed scattered light at 2536Å is close to the specifications at distances less than 10 px from the line center, and much better than specifications at 50 and 100 px. The near wings of the 2536Å line are shown in Figure 1.

At 4358Å, however, we discovered that the mercury lamp emits a continuum at a level of 2×10^{-3} relative to the peak. Within 50 px of the line center, this continuum passes through the filter, making it impossible to determine the amount of scattered light, unless the filter transmission is calibrated with a flat-field source. The region centered on 4358Å is shown in exposures with and without the narrow band filter in Figure 3. In the next calibration effort we will obtain a complete Hg spectrum and try to find another spectral line that is not superimposed on a continuum. A line at 5461Å is a good candidate. In any case, we will determine the transmission curves of the narrow band filters, so that the continuum can be subtracted, if necessary. A low level continuum may also be present in the vicinity of λ2536. We will make an unfiltered exposure of the line in the

next calibration to ascertain whether the continuum is a problem here. The long-exposure profile of the 2536Å line is shown in Figures 2a and 2b. Because the narrow band filter is not perfect, two nearby lines at 2652.0 and 2482.0Å leak through the filter. These are marked in Figure 2a. A series of fringes (intensity < $1x10^{4}$) occurs between 40 and 100 px from the center. Both the 2536Å and 4358Å lines are slightly asymmetric between distances of 2 and 30 px from line center.

Additional exposures of the 2536Å line with gratings H19 and H13 (Figs 4 and 5) were made to determine whether scattered light can leak onto the detector when other gratings are used. On grating H19, four lines ranging from $1x10^{-5}$ to $3x10^{-5}$ of the peak intensity are visible. On grating H13, there is one bright line with an intensity of $1.6x10^{-4}$. Exposures of the 4358Å line with gratings H27, H13, L65, L15 and the prism are shown in Figures 6-10. The brightest features on gratings H27 and H13 have an intensity well below $1x10^{-4}$. A noisy diode (px 145), with a count rate of 10 cts per second, appears on both 50s exposures. This was the diode where the previous λ2536 line was located. Apparently, the peak count rate of 2×10^{6} cts/s in the 25s B3 (1.0 arcsec) exposure of that line made the diode noisy. When this calibration is repeated, we will reduce the lamp brightness to eliminate the problem. Three broad, saturated peaks dominate the L65 spectrum, corresponding to the zero order, 1st order and 2nd order spectra. In between these peaks, the greatest scattered light intensity is $1.5x10^{-4}$. A zero order peak is the only feature above $1x10^{-4}$ on the L15 spectrum. Finally, the prism spectrum shows no features above $1x10^{-4}$ apart from the 4358Å line. These intensitites normalized to the line peak on grating H40. The scattered light on the low-resolution dispersers is best normalized to the peak on the grating on which

the spectrum was taken. This will be done once the relative efficiences of the gratings are known.

Conclusions

The scattered light on grating H27 is well within the specifications if the effect of the 60 Hz light source at high count rates is taken into account. To verify this, we will reduce the lamp brightness to 1000 cts/s at 2536Å, in the next scattered light calibration. Light from the 2536Å line also scatters onto grating H13, producing a sharp line of intensity 1.6×10^{-4} at pixel 430, which is probably due to multiple reflections between the grating and the collimating mirror. The distant wings are within the specifications except for this effect of multiple reflections. The scattered light from the 4358Å line could not be measured because it was less than the continuum at that wavelength in the near wings. Another line not affected by continuum will be used in the next calibration. However, a determination of the transmission curve of the narrow band filter will make possible a subtraction of the continuum.

Table 1: Scattered light measurements, blue detector.

λ (Å)	Grating	Distance from Line Center (Px)	Observed Scattered Light Long Exp.	Observed Scattered Light Short Exp.	Specifications
2536Å	H27	2		1.5×10^{-2}*	1×10^{-2}
		6		2×10^{-3}	1×10^{-3}
		10		6×10^{-4}	5×10^{-4}
		50	2.5×10^{-5}		2×10^{-4}
		100	$< 1\times10^{-5}$		1×10^{-4}
			Peak	Continuum	
	H19		3×10^{-5}	3×10^{-6}	1×10^{-4}
	H13		1.6×10^{-4}	3×10^{-6}	1×10^{-4}
			Peak	Continuum	
4358Å	H27		9×10^{-6}	$< 1.0\times10^{-6}$	1×10^{-4}
	H13		$<1\times10^{-6}$	$< 1.0\times10^{-6}$	1×10^{-4}

* The λ2536 values are not corrected for the effects of the 60Hz lamp at high count rates.

FIGURE CAPTIONS

Figures 1-3 are normalized to the total counts in the intergrated line profile. The FOS scattered light specifications are indicated by the symbol +.

Figure 1. A 1s exposure of the near wings of λ2536 on grating H27 through the 0.1 arcsec aperture. Figures 1, 2a and 2b have not been corrected for the non-linearity effects of a pulsed light source at high count rates.

Figure 2a. Long exposure of the far wings of λ2536. 25 sec expsoure with 1.0 arcsec aperture. The central 200 px of the spectrum is shown here.

Figure 2b. Entire spectrum obtained with grating H27 as in Fig 2a.

Figure 3 Dashed line: exposure of λ4358 without narrow band filter, showing the emission line superimposed on a continuum. Solid line: exposure with filter, which transmits some of the continuum within 40px of the line center.

Figure 4 A 25s exposure at 2537Å with a 1 arcsec aperture, which shows the scattered light on H19. The relative intensity of the brightest scattered light feature is indicated.

Figure 5 λ2536 light scattered onto the detector when grating H13 is used, showing one bright feature exceeding the specifications. A 25s exposure.

Figure 6 λ4358 light scattered onto the detector when grating H27 is used. A 50s exposure with 1.0 arcsec aperture. There is a noisy diode at px 145.

Figure 7 λ4358 light scattered onto the detector when grating H13 is used. A 50s exposure.

Figure 8 A 25s exposure with a 1.0 arcsec aperture of the λ4358 line with grating L65, showing zero order, first order, and second order peaks.

Figure 9 Exposure of λ4358 line with grating L15, showing the zero order peak and absence of ghost lines.

Figure 10 A 25s exposure with a 1.0 arcsec aperture of the λ4358 line with the prism, showing a saturated line profile.

Fig. 1

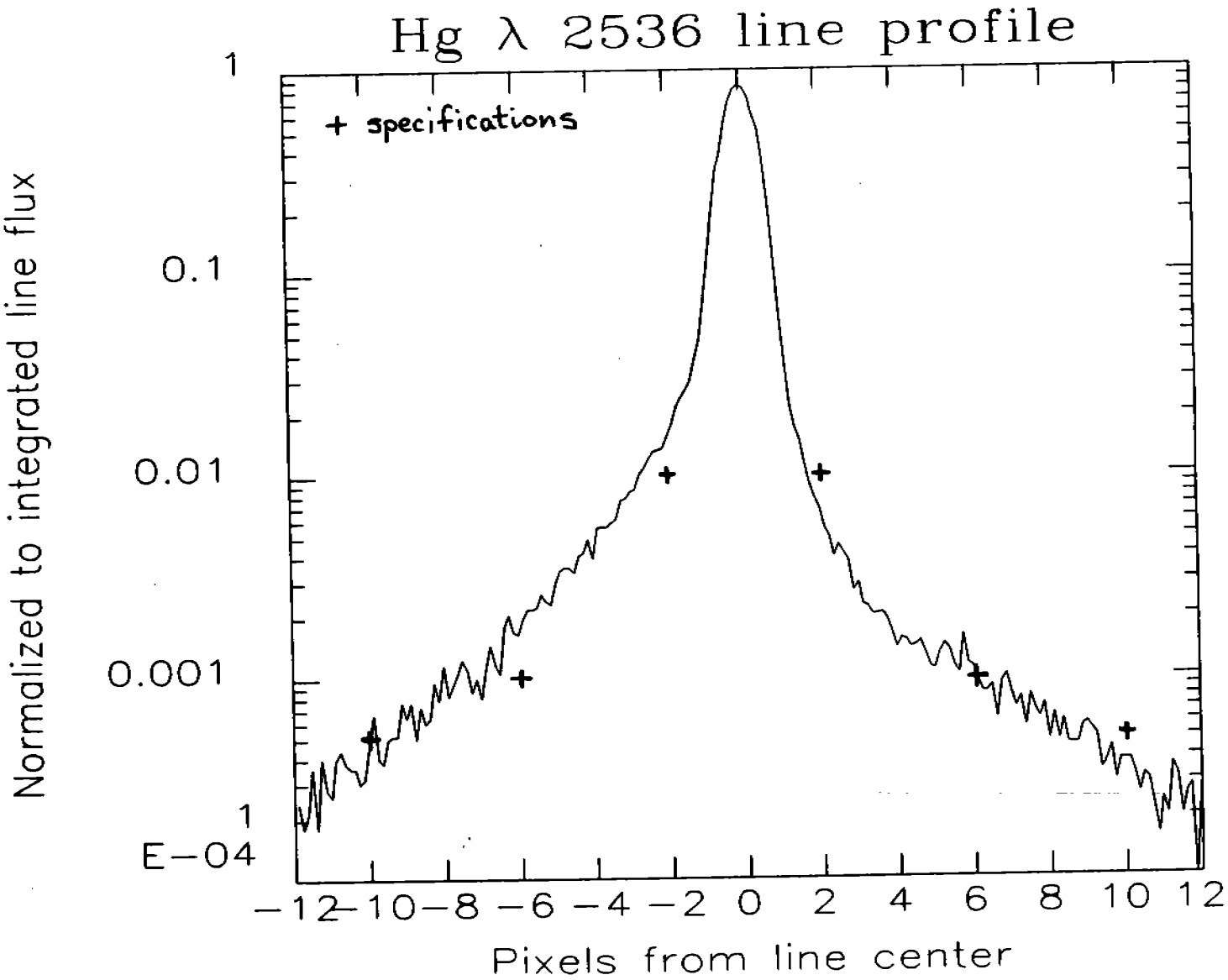
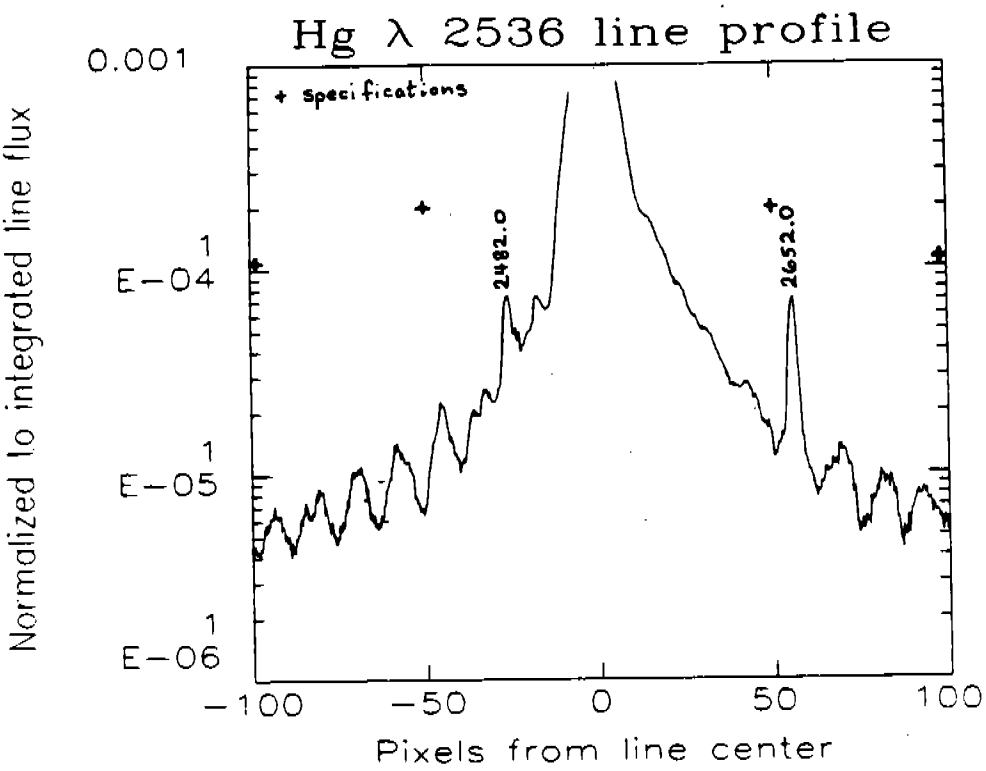
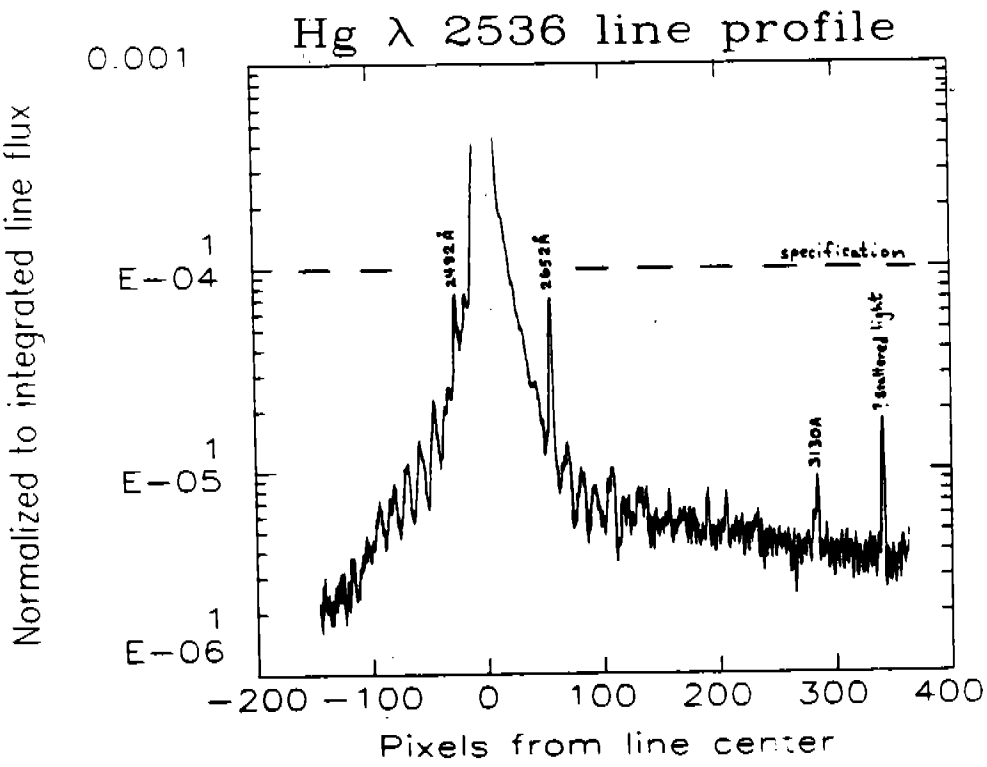

Hg λ 2536 line profile
+ specifications
Normalized to integrated line flux
1
0.1
0.01
0.001
1
E−04
−12 −10 −8 −6 −4 −2 0 2 4 6 8 10 12
Pixels from line center

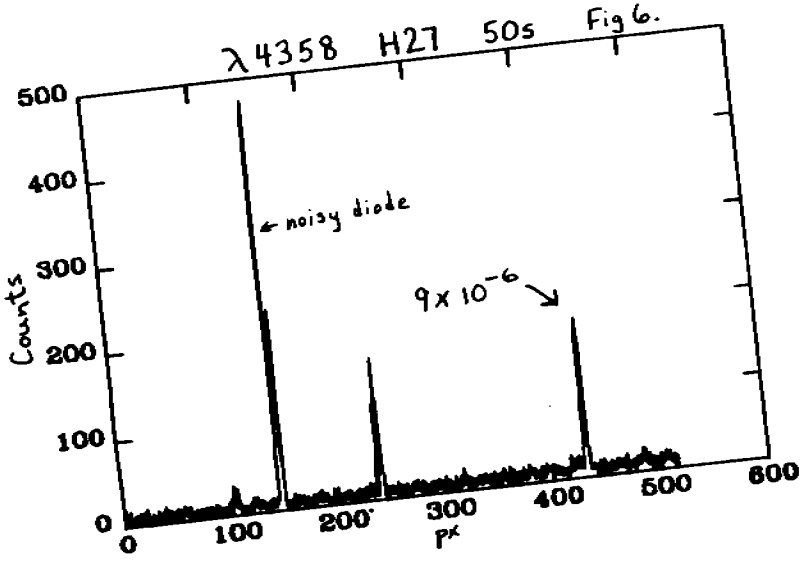
Fig. 2a

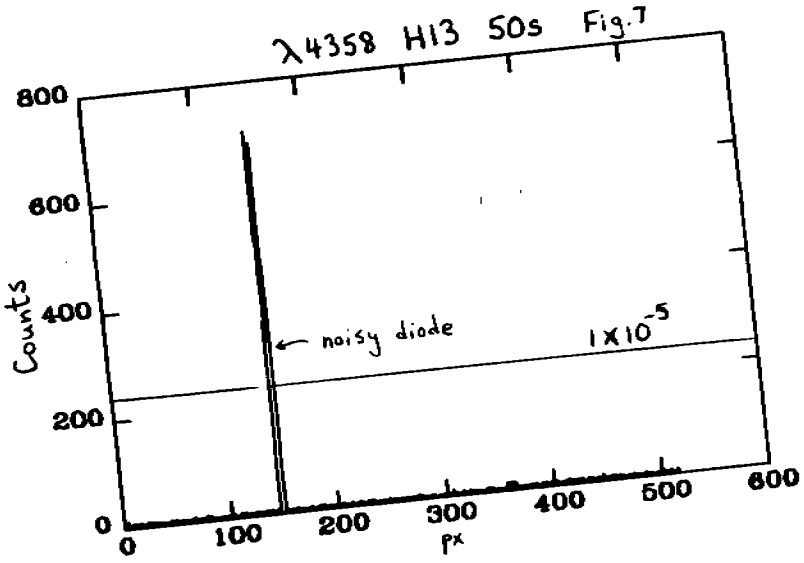


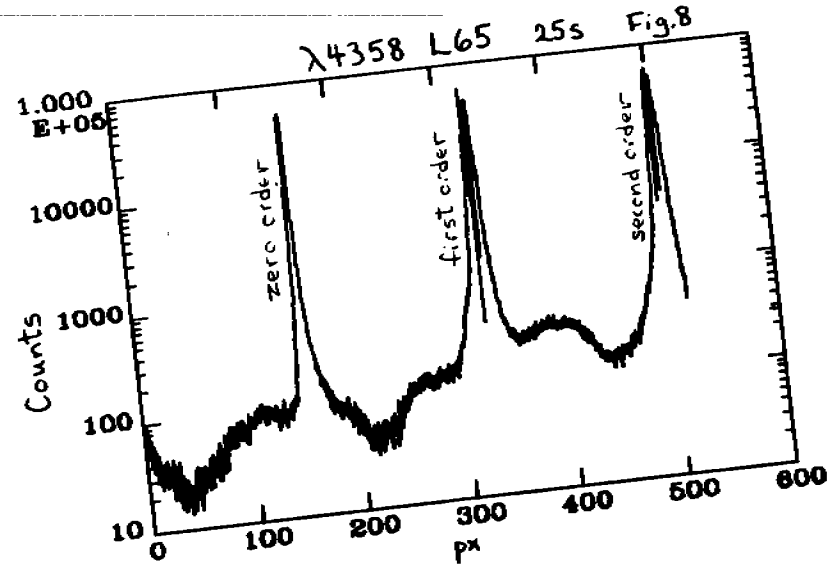
pixel = diode = 50μ
= 2.09 Å

Fig 2b




λ4358 H27 50s Fig 6.
Counts
px
noisy diode
9x10⁻⁶
0
100
200
300
400
500
600


λ4358 H13 50s Fig.7
Counts
px
noisy diode
1X10⁻⁵
0
200
400
600
800
100
200
300
400
500
600


λ4358 L65 25s Fig.8
Counts
px
zero order
first order
second order
1.000 E+05
10000
1000
100
10
0
100
200
300
400
500
600

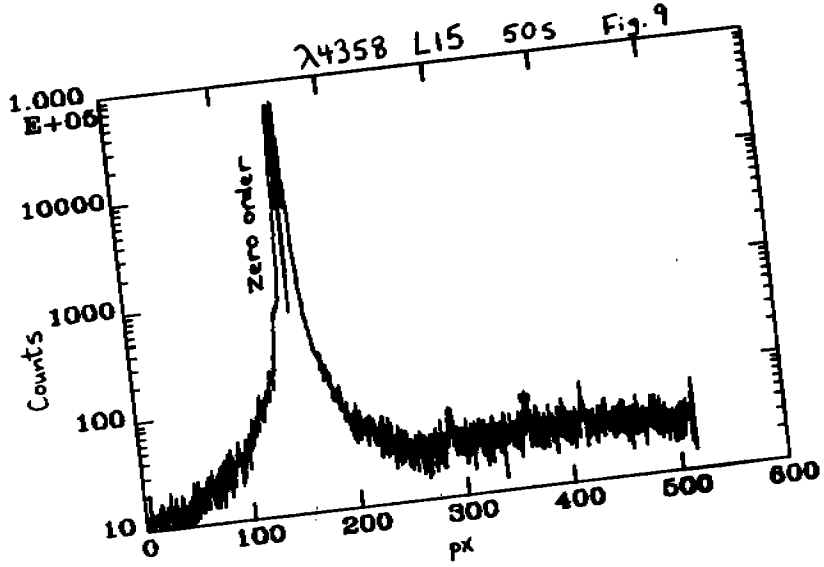
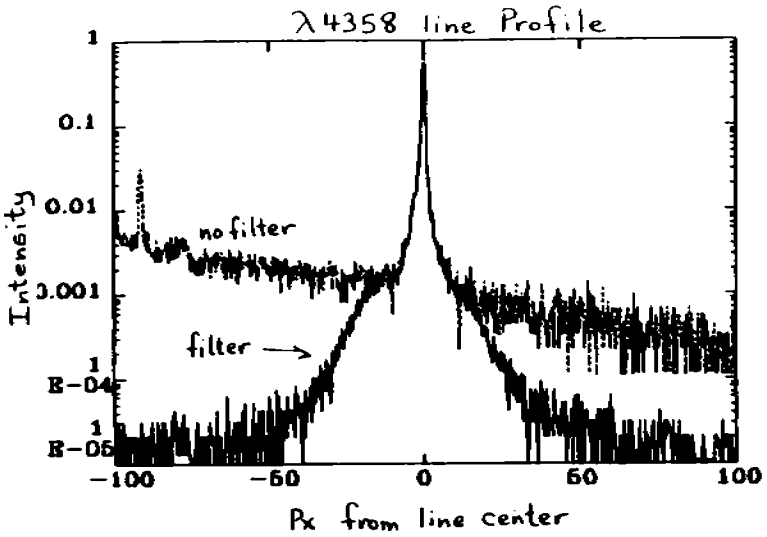
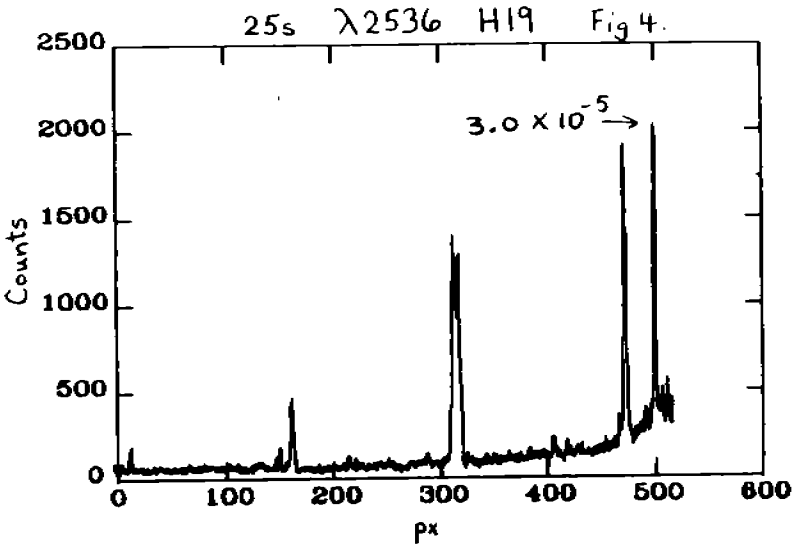
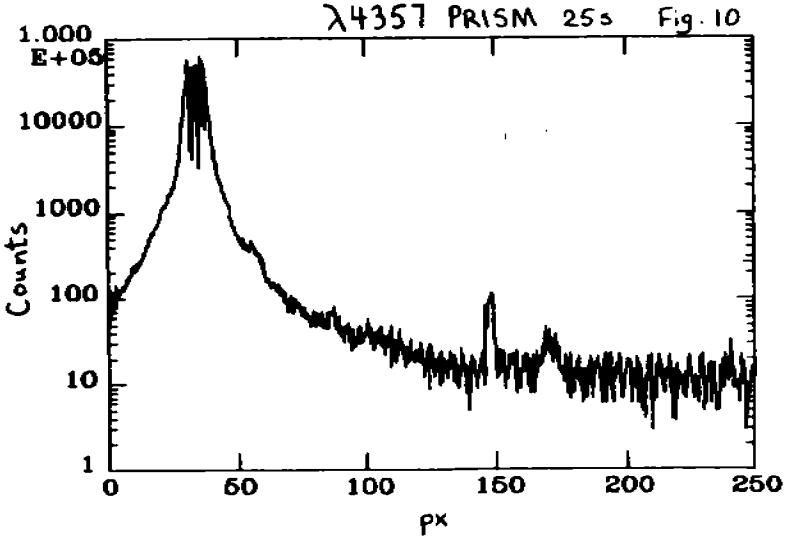
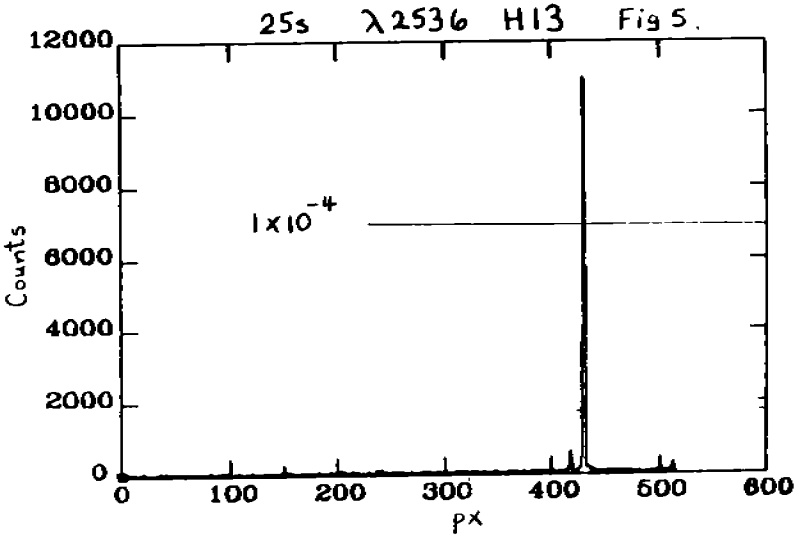

λ4358 L15 50s Fig.9
Counts
px
zero order
1.000 E+05
10000
1000
100
10
0
100
200
300
400
500
600

Figure 3.


λ4358 line Profile
Intensity
1
0.1
0.01
0.001
1 E-04
1 E-05
no filter
filter
−100
−50
0
50
100
Px from line center


25s λ2536 H19 Fig 4.
Counts
2500
2000
1500
1000
500
0
3.0 X 10⁻⁵
0
100
200
300
400
500
600
px


λ4357 PRISM 25s Fig. 10
Counts
1.000 E+05
10000
1000
100
10
1
0
50
100
150
200
250
px


25s λ2536 H13 Fig 5.
Counts
12000
10000
8000
6000
4000
2000
0
1 x 10⁻⁴
0
100
200
300
400
500
600
px