a. Kinney - SIB

BACKGROUND DUE TO SCATTERED LIGHT

CAL/FOS-103

A. L. Kinney & R.C. Bohlin
September, 1993

SUMMARY

Like all dispersing optics, the FOS gratings and prism produce a diffuse component of scattered light that adds to the detected counts per second. The pipeline currently subtracts only the dark count background and should be changed to include the scattered light contribution to the background. For the gratings which have regions of no sensitivity, those regions can provide a more accurate measure of total background than currently used.

DISCUSSION

The FOS pipeline currently subtracts a default background from FOS spectra which is dependent on the position in the orbit and, thus, reflects the dark counts present on the detector due to geomagnetic position of the telescope (see Koratkar 1993, Rosenblatt et al. 1992). However, the scattered light component from the gratings is not removed by this method.

About half of the FOS dispersors produce spectra with wavelength regions of no sensitivity to the dispersed light because of optical cutoffs. (see Figure 1.2.1 in the FOS Instrument Handbook, Kinney 1993). These regions can be used to get a direct measurement of the scattered light component for each individual observation. The background subtraction in the pipeline reductions for FOS can then be improved by subtracting the average background in the regions of the gratings which have no sensitivity to the properly dispersed light.

Figure 1 (thanks to M. Eracleous) demonstrates the case of a spectrum taken on the blue side, in grating G160L, with the 1.0″ circular aperture, where there is no sensitivity in the region from 0 to 1199 pixels, except for the zero order, which falls approximately between pixels 600 and 670 (McClintock et al. 1993). An average is measured (as shown by the solid line in Fig. 1) in the region from 900 to 1199 pixels, where there is no sensitivity. In contrast, the pipeline dark count background is given by the dashed line. In the case of this spectrum, the pipeline background would lead an observer to conclude that there is detected continuum flux in the region from 1200 to 1900 pixels, while the subtraction of the more realistic background shows that there is not a detection. The slight wavelength dependence in the background comes from the observers method of scaling the dark background to the total scattered light plus dark count background, and using the wavelength dependence of the dark background (Rosenblatt et al. 1992). Instead, we recommend simply subtracting a constant from the .c5d file, which already has had the dark count subtracted, since we don't expect the wavelength dependence of the scattered light background to be the same as the wavelength dependence of the dark background.

Figure 2 (thanks to K. Korista) shows the scattered light plus the dark count background as determined by the method above, as compared to the dark count background for an object that is variable. The fact that the background increases as the count rate of the object increases verifies that the background is largely scattered light. As the object

flat field subtracted?

decreases in flux, the observed background approaches the dark background, as expected if the background comes from both scattered light and from the dark counts.

For the gratings which have regions of no sensitivity, we compile in Table 1 the minimum pixel number, maximum pixel number, and total pixels of the region appropriate to calculate an average scattered light component. The algorithm for calculating the background to be subtracted is then simply:

$$S = \frac{\sum_{Min}^{Max} C}{Total}. \tag{1}$$

$$C' = C - S \tag{2}$$

where S is the scattered light background, C is the counts s^{-1} from the .c5h and the .c5d files, C' is the net counts s^{-1} corrected for scattered light and for any error in the dark count model, and Min, Max, and $Total$ are the minimum pixel, maximum pixel, and total number of pixels in the region not sensitive to dispered light, as given in Table 1.

The value of the subtracted background should go in a header keyword, but should *not* be added to the existing .c7h and .c7d background files. The .c5h and the .c5d files *should* have the constant scattered light subtracted. The uncertainty in the mean of the scattered light background can be computed from the scatter in the data by

$$\sigma = \sqrt{\frac{\sum_{Min}^{Max}(C - < C >)^2}{Total \times (Total - 1)}}. \tag{3}$$

The uncertainty is in units of counts s^{-1}. Alternatively, σ could be computed from the counting statistics. When σ is propagated to the flux calibrated file, the uncertainty is no longer a constant. This systematic uncertainty could be tracked as a separate file in the PODPS output products.

The method presented here for measuring the scattered light background for those gratings which include regions with no sensitivity is an improvement over the current pipeline background subtraction, as demonstrated in Figure 1. More accurate absolute flux distributions will result from the use of Eq. 2, since the FOS sensitivities derived by Neill, Bohlin, & Hartig (1992) used that algorithm (except for the Blue Prism) to derive the FOS absolute calibrations. However, this simple method addresses neither the more complex issue of wavelength dependence of the background, nor the scattered light correction for the grating modes that are omitted from Table 1. Cycle 3 and cycle 4 calibrations of scattered light from bright stars should "shed some light" on the wavelength dependence of scattered light so that the scattered light component can be better characterized in the future.

TABLE 1
Pixel Numbers for Background Subtraction

Grating	Side	*Min*	*Max*	*Total*
G130H	Blue	30	129	100
Prism	Red	0	899	900
Prism	Blue	1860	2059	200
G190H	Red	2040	2059	20
G780H	Red	10	149	140
G160L	Blue	900	1199	300
G160L	Red	600	899	300
G650L	Red	1100	1199	100

REFERENCES

Kinney, A.L. 1993 *FOS Instrument Handbook, Version 4.0*

Koratkar, A.P. 1993 *FOS Data Reduction Handbook*

McClintock, J., Horne, K., et al. 1993, in preparation

Neill, J.D., Bohlin, R.C. & Hartig, G.F. 1992, CAL/FOS-077

Rosenblatt, E.I., Baity, W.A., Beaver, E.A., Cohen, R.D., Junkkarinen, V.T., Linsky, J.B., & Lyonse, R.W. 1992, CAL/FOS-071

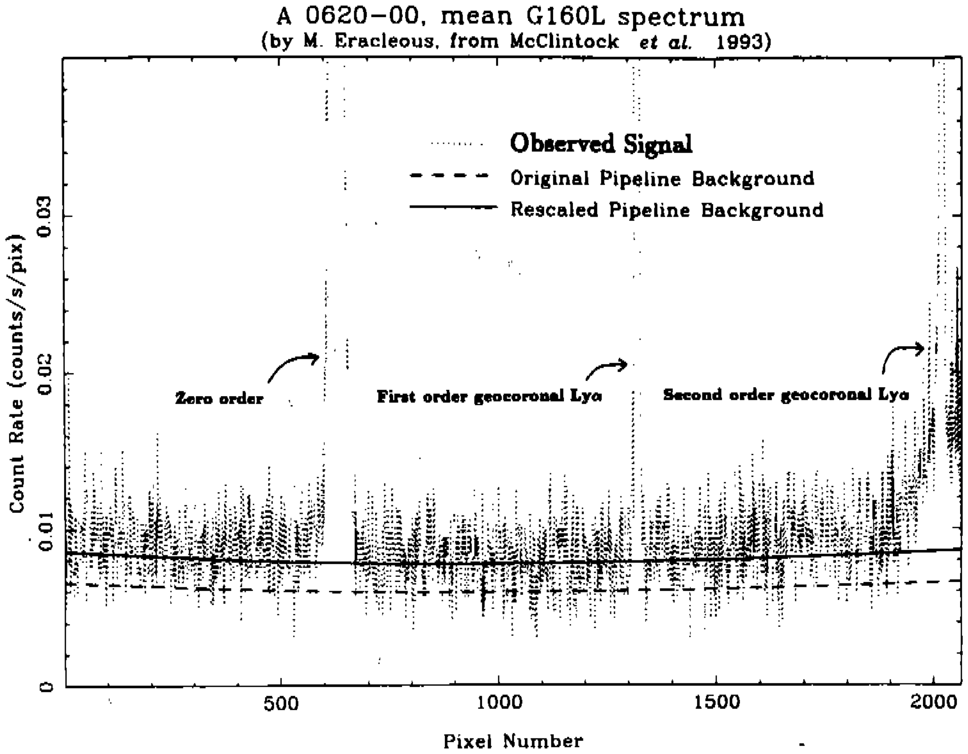

Figure 1. An FOS spectrum, with the uncorrected count rate shown as a dotted line, the pipeline background shown as a dashed line, and the rescaled background shown as a solid line.

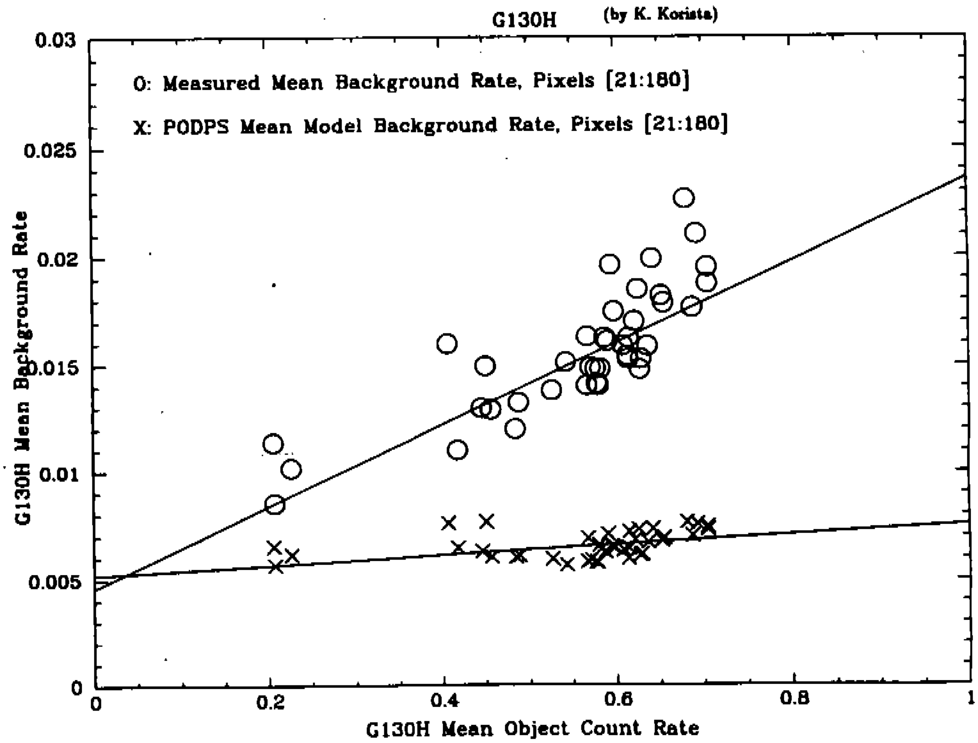

Figure 2. The background is plotted versus the mean count rate for a variable object. The circles show the background as determined from regions of no sensitivity, in a method similar to that described in this report. The crosses show the pipeline dark count background. When the object is brighter, there is a larger measured background. As the object decreases in flux, the measured background resembles more and more closely that of the predicted dark count background. These points together are a clear indication that the discrepancy in backgrounds is due to the scattered light.