1997 HST Calibration Workshop
Space Telescope Science Institute, 1997
S. Casertano, et al., eds.

Estimating Scattered Light in the FOS

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Abstract.
We quantitatively assess the impact of grating scatter within the FOS as a function of intrinsic target spectrum and spectral element employed. `bspec`, the FOS scattered light optical modeling code of Micheael Rosa, has been used for this analysis. In this poster we present an example from an atlas of spectra (published in FOS ISR 151) illustrating the amount of predicted scattered light for all high dispersion gratings with both FOS detectors for a representative range of colors and object types. As has been qualitatively noted previously, we find that the intrinsic color of the observed object can affect the amount of scattered light detected and that this scattered light is, in most cases, wavelength independent. For the limited number of spectral elements to which it can be applied, the standard FOS pipeline scattered light correction is, therefore, a good approximation. The figures included in the above mentioned ISR can be used as a guide in estimating the degree of scattered light contamination in spectral regions for which the standard pipeline algorithm can not be applied.

1. Background

The Faint Object Spectrograph (FOS) is a single pass spectrometer with blazed, ruled gratings. Both the FOS/BL and FOS/RD detectors are sensitive to wide spectral ranges. Therefore, the FOS is subject to "scattered" light which originates primarily in the diffraction patterns of the gratings and the entrance apertures, as well as in the microroughness of the gratings due to their ruled surfaces. These characteristics are due to basic physical principles, which we assume throughout this paper can be utilized to model the practical impact of grating–scattered light on routine FOS observations.

Additional scattering due to the contamination of optical surfaces or unbaffled stray light may worsen the situation. Fortunately, the analysis of laboratory and on-orbit Science Verification (SV) FOS data (Uomoto *et al.* 1989, Bartko *et al.* 1992) shows that the actual instrument performance is very close to that expected from ideal optical surfaces and that the HST primary mirror is essentially smooth at UV wavelengths. The SV analysis, based upon measures of white dwarf BD+75°325 with FOS/BL and G130H, G190H and G160L gratings, verified that detected scattered light was limited by grating–scatter and was within pre-launch specifications.

In an examination of on-orbit science data for targets of a wide range of known color, E. Kinney and R. Gilmozzi (1994) pointed out that FOS grating–scatter contamination is particularly obvious for observations of late type stars in the UV range ($\lambda\lambda \approx$ 1150-2100Å). This scattered light appeared to be wavelength independent, and to depend on the magnitude and color of the target object only. This result was confirmed by the parallel study of Rosa (1993).

The result of all these analyses was that A. Kinney and Bohlin (1993) recommended that the calibration pipeline for FOS data be modified to correct for grating–scattered light when possible. The correction algorithm determines the mean detected signal for those diodes that are insensitive in a given dispersed spectrum and uses this mean as a measure of the wavelength-independent scattered light for the entire spectral range of the grating. This scattered signal is subtracted as a constant from all diodes in the spectrum. We note that not all FOS data can be so corrected as all diodes are illuminated by dispersed light in some FOS detector/disperser combinations. This procedure was implemented in the calibration pipeline in March 1994, and subsequently modified in February 1996 to use the median, rather than the mean, with the additional proviso that all deviations from the mean greater than 4σ are eliminated in order to remove the impact of particle hits from the determination of the correction.

To further aid the observer, Bushouse *et al.* (1995) incorporated into the STSDAS software package a pair of tasks that would allow one to *estimate* the amount of scattered light in any type of observation carried out with the FOS (the so- called "`bspec`" package (Rosa 1994a). We have used `bspec` to model the predicted grating-scatter for a representative sample of stellar types and object types that have been observed with the FOS. This report announces an atlas of these `bspec` predicted spectra that will allow users of FOS exposures to estimate the degree to which their FOS data is affected by grating–scattered light.

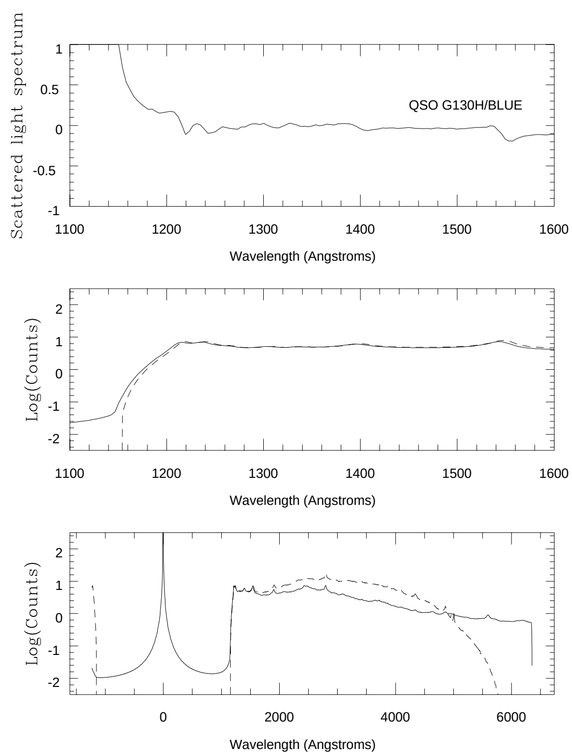

Figure 1. The lower two panels display scattered+intrinsic light (solid line) and the intrinsic light (dashed line) for a QSO as dispersed by the FOS/BL G130H grating. The upper panel indicates the ratio of scattered to scatterd+intrinsic light in the spectral region of interest.

2. Example

We present a sample from FOS ISR 151: a QSO with the FOS/BL G130H grating. The reference spectrum was re-normalized to V = 15 (at the fiducial wavelength of 5556Å), through the 1.0″ aperture, and with COSTAR inserted in the optical path using the Synphot task `calcspec`. We then ran the data through the task `countspec`, which takes a re-normalized spectrum and produces an FOS countrate spectrum. The task convolves the observed absolutely calibrated flux spectrum with the throughput functions of the FOS optical components to produce a corresponding spectrum that is in units of counts per second per pixel. The last step in the procedure is to run the result through the task `bspec`. Details are left to the ISR, but the result is that an *estimate* is made of the amount of scattered light in a given target from `bspec` by plotting some of the output of that task: the quantities of most interest are "gwav" (wavelength); "ablg" (the total of intrinsic+scattered light countrate spectrum); and "benv" (the total intrinsic light countrate spectrum). Figure 1 shows a sample of the results as presented in FOS ISR 151 to which we refer the reader for a more complete and throrough discussion of all these points.

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