FOS Red Detector Flat-field and Sensitivity Degradation

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Abstract

Significant degradation of the efficiency and fixed pattern noise characteristics of the FOS Red Digicon in an approximately 200Å–wide band centered at about 1950Å has been detected in observations spanning 10 months. The drop in efficiency amounts to about 10% at the center of the band and the strength of apparent absorption features, with typical widths of 5–10 diodes, has increased in by up tp 15% between Dec 1990 and Sept 1991. No such degradation is observed on the Blue detector. The effect may be due to the development of color centers in the fused silica faceplate of the Red detector due to the radiation environment of the HST spacecraft. A lab test to confirm this hypothesis and a calibration program to monitor the development of the effect have been initiated.

Data obtained with the FOS Red detector from SV tests 1318 (Spectral Flat Fields) and 1320 and 3106 (Absolute Sensitivity Calibration) have shown a marked growth, over the past 10 months, in the amplitude of fixed pattern noise in the spectral region around 1950Å. This has been accompanied by an approximately 15% sag in efficiency over the same range (Figure 1). The effect is seen in spectra produced by both the G190H and G160L gratings, at very different locations on the photocathode. The detailed wavelength dependence of the structure differs for the two gratings (Figure 2) and varies, to a lesser extent, between the spectra produced by the paired and single apertures (separation of 420μ in the cross-dispersion direction). No such effect is seen in spectra obtained with the Blue side. The problem is probably not caused by contamination of the FOS optical surfaces, since we would expect to see similar effects on both sides, if that were the case. Furthermore, the wavelength dependence should be independent of photocathode location if absorption by a contaminant is the cause. Rather, we hypothesize that the effect is due to the development of color centers in the fused silica (Suprasil-1) window of the Red detector, as a result of the on-orbit radiation environment. Thus, the faceplate would appear mottled and 'gray' when viewed in 2000Å light, but clear at longer wavelengths. Similar degradation of fused silica aboard the OAO-2 spacecraft has been reported (Savage,B.D. 1975, ApJ **199**, 92). The Blue Digicon has a magnesium fluoride faceplate, which apparently is more robust to energetic proton irradiation.

To test this hypothesis, a flight spare faceplate has been sent to Walt Fowler (retired from GSFC), who will irradiate it at the Harvard Cyclotron with a proton energy spectrum intended to model that seen through the SAA by a thin-skinned spacecraft. The faceplate will be included with a sample of filter glasses being tested for the STIS program in December. The plan is to measure the bulk faceplate spectral transmissivity both before and after irradiation with a dose that represents several (TBD) years of HST orbital operations. If a dip in response sismilar to that of the Red FOS detector is seen, we may want to examine the structure by scanning with a small (order 100μ) beam, imaging the faceplate onto a spare Digicon at UCSD or onto a visible phosphor screen for direct visual examination.

The continuing loss of efficiency and degradation of uniformity in the affected spectral region will have significant consequences for the FOS science and calibration programs. The G190H grating is used for many programs, including the quasar absorption line survey Key Project (J. Bahcall, PI), which relies on accurate flat-fielding to detect weak absorption features. While this spectral region is also covered by the Blue detector, its efficiency is approximately half that of the Red detector.

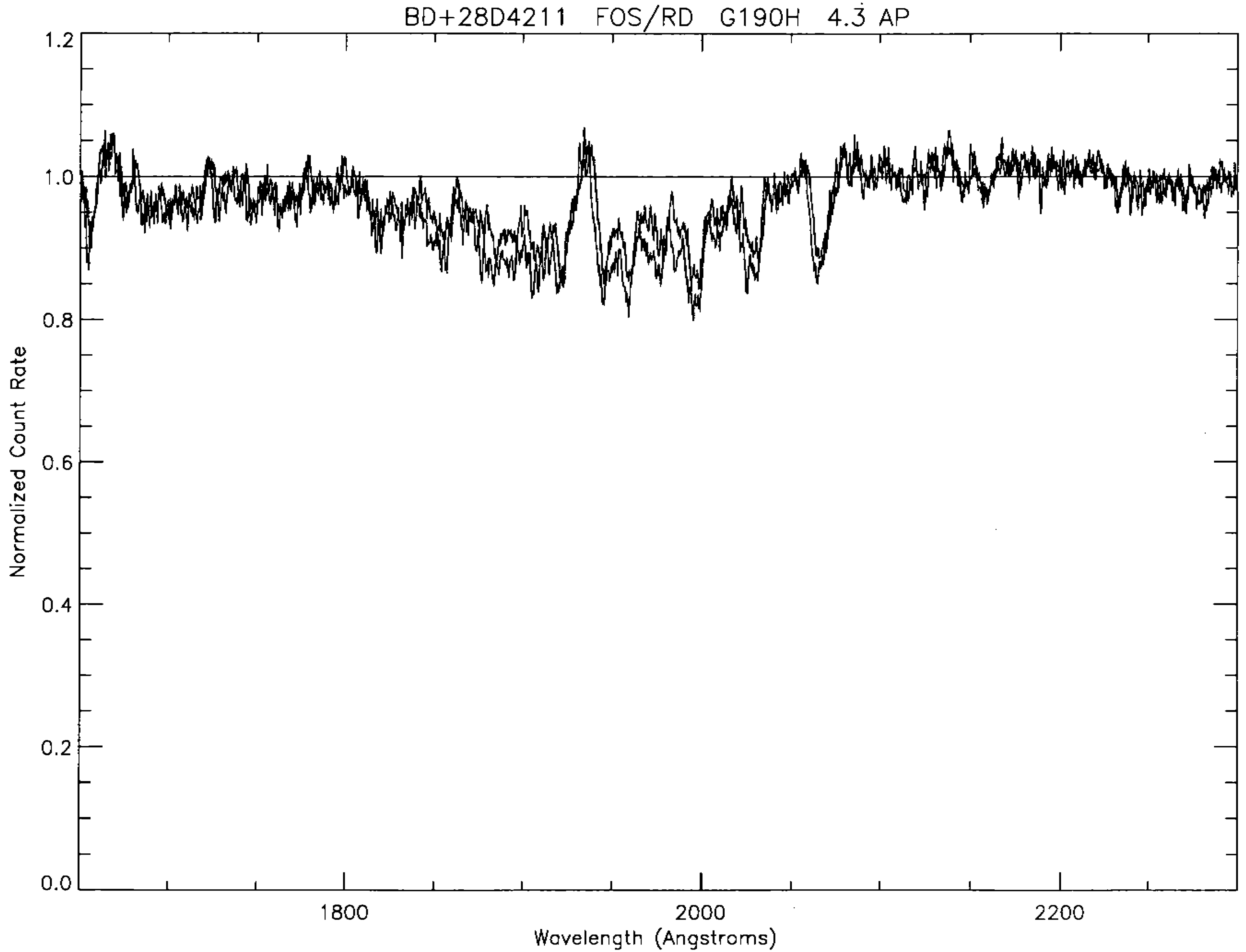
Clearly the flat-field and throughput characteristics of the Red detector must be monitored frequently, if accurate data reduction is to be possible. We have defined an augmentation to the FOS Cycle 1 calibration program designed to monitor the G190H and G160L spectra of standard stars on a monthly basis, starting in late December. Because the reduction of the resulting data and delivery of updated flat-field and inverse sensitivity reference files will inevitably lag behind the science observations, re-reduction of science data will routinely be required.

Programs requiring precise spectrophotometry or equivalent width measurements within the affected wavelength region may be best carried out with the FOS Blue side if the lower observing efficiency of that detector can be tolerated (as may be the case for bright targets).

Figure Captions

Figure 1. Ratio of FOS/RD G190H spectra through the 4.3 aperture of the white dwarf standard BD+28D4211 obtained on 15 Jul 91 and 27 Sep 91 to the baseline observation of 2 Dec 90. A trough centered at about 1950Å has developed, and the significant fixed pattern noise that was obvious in the baseline observation has doubled in amplitude, and is apparently continuing to grow.

Figure 2. Comparison of the fixed pattern noise seen in the FOS/RD G190H and G160L spectra of white dwarf KPD0005+5106, obtained on 1 Jul 91, as a function of wavelength. Both spectra show strong structure in the 1800-2100Å region but the wavelength dependence is not correlated.



BD+28D4211 FOS/RD G190H 4.3 AP
Normalized Count Rate
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1800
2000
2200
Wavelength (Angstroms)

Figure 1

Standard Star Comparison FOS/RD G190H SINGLE AP

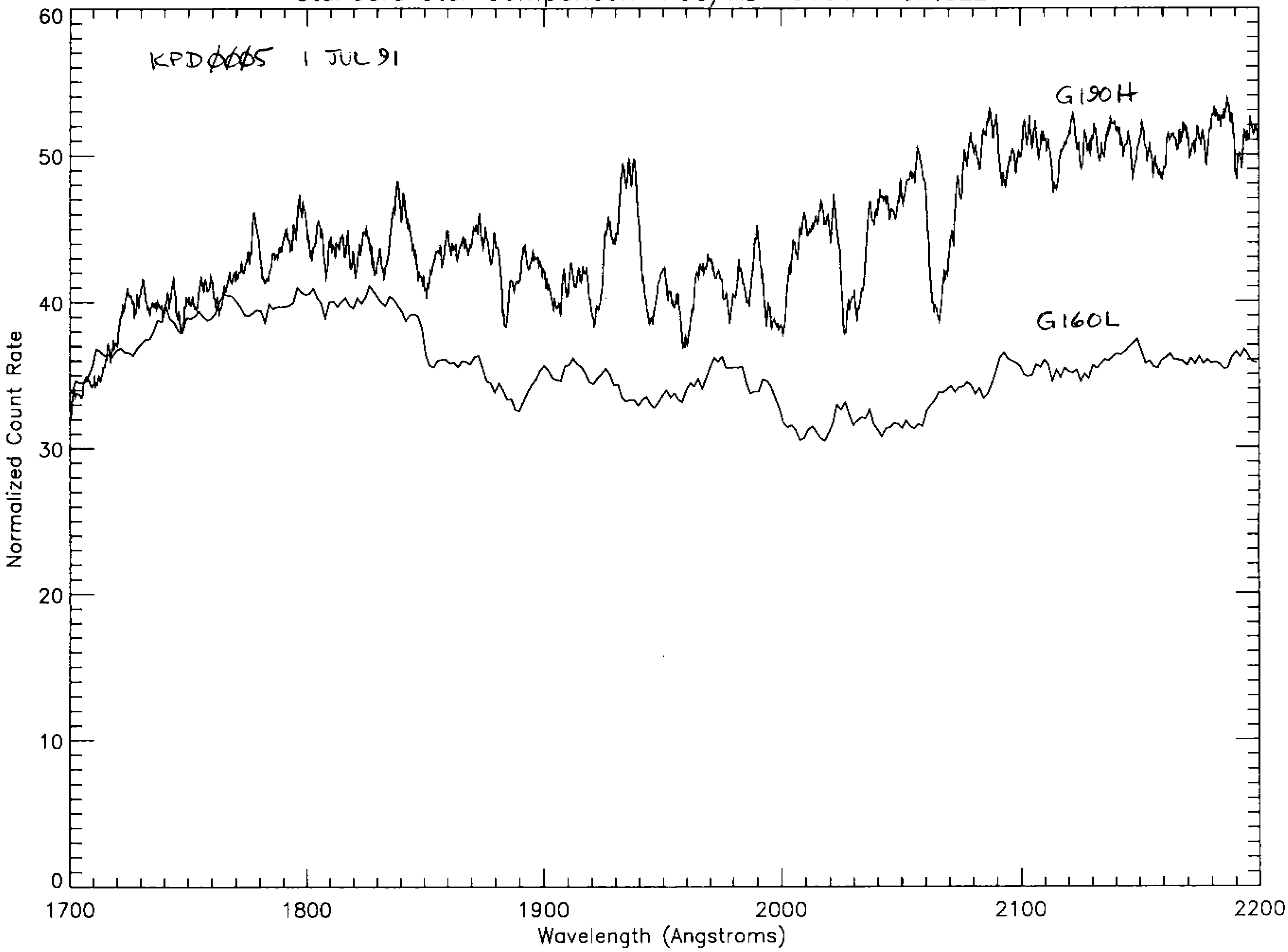


Figure 2