Redetermination of Sensitivity for Echelle-B

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ABSTRACT

This ISR describes a complete redetermination of the GHRS sensitivity for the Echelle-B grating. The procedures used to derive the corrected sensitivity functions are described here, and new files have been installed in the CDBS.

1. Introduction

Calibrating GHRS spectra involves translating the observed pixel position to wavelength and the observed counts to units of flux. Wavelength determination is relatively straightforward, relying on observations of the wavelength calibration lamp within the instrument. Flux calibration, on the other hand, is based on observations of standard stars which contain a number of absorption features and a detector whose response can vary with wavelength, spatial position, and time. These factors must be taken into careful consideration when determining the sensitivity function for a given grating.

When comparing the pipeline-calibrated flux spectrum for the standard star μ Col, taken with Echelle-B, with its expected reference flux, a significant deviation was apparent, indicating that the sensitivity function that was made available in SMOV was incorrect. The extent of these corrections and the procedure for redetermining the sensitivity is outlined in sections 2 and 3.

2. Sensitivity Determination

"Sensitivity" is the function used to convert detected count rates to absolute flux values. It is defined as the flux per count rate, $S_\lambda = F_\lambda / C_\lambda$, in units of (erg cm^{-2} s^{-1} Å^{-1}) per (counts s^{-1} diode^{-1}). Sensitivity determination involves first the observation of a standard star over the full useful range of the grating, giving a standard spectrum, in units of count rate, as a function of wavelength. This spectrum is to be ratioed with the reference spectrum for the standard star, the true representation of flux at each wavelength. Figure 1 shows the observed spectrum, C_λ, of the standard star μ Col, plotted with its reference spectrum, F_λ, taken with the IUE, found in the CDBS CALOBS directory.

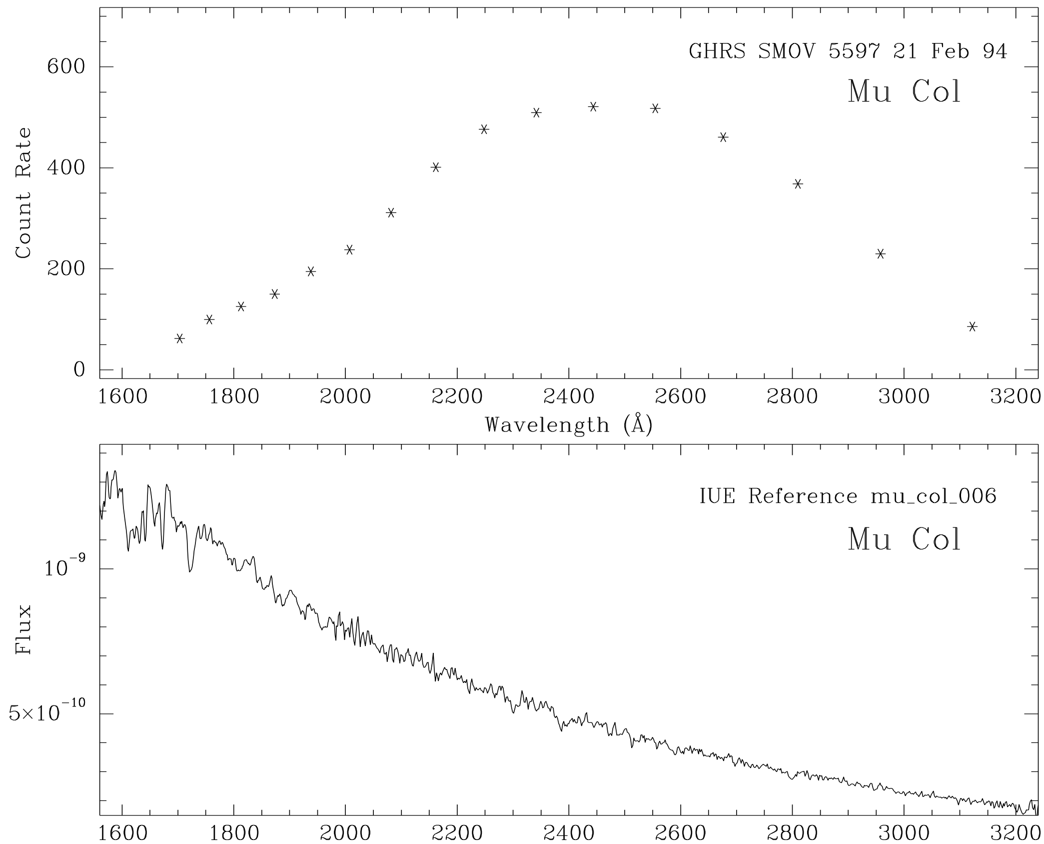

Figure 1: Observed spectra C_λ of standard star μ Col with GHRS Echelle-B compared to its reference spectrum F_λ taken with the IUE.

3. The Calibration of Echelle-B

Preliminary analysis of Echelle-B began with the LSA Cycle 4 observations of μ Col from the GHRS Ech-B Sensitivity Calibration on April 21, 1994. Table 1 lists the files used with their corresponding aperture, exposure time, grating order, and central wavelength. These files were calibrated through the pipeline using the most recent reference files and the STSDAS task `hst_calib.calhrs`. Header switches were set as described in GHRS-ISR-085 for the calibration of G140L (with the exception of ECH_CORR=PERFORM) and are given in Table 2.

In determining whether the recommended sensitivity file for these observations (e5v0936oz.r3h) is adequate, we must compare the flux calculated using this sensitivity with the reference spectrum for the same star. The Echelle-B files, however, cover only a narrow bandpass per exposure (~10 Å at 1700 Å and ~15 Å at 3100 Å), and are separated by wavelengths on the order of 40 Å and 150 Å for the Cycle 4 observations. For this reason, it was not possible to overplot the spectra and take a simple ratio because the observations are not continuous over the entire range of wavelengths. It was thus useful to determine the average flux over the band for each file and overplot onto the reference file. These results (Figure 2a) show that the flux for Echelle-B deviates significantly from what we expect. The flux ratio for each wavelength was determined by averaging the observed flux over the entire bandpass for each data point, and dividing by the reference spectrum over the same wavelength range. The result is that the recommended sensitivity file overpredicts the flux by ~35% at 1800 Å and underpredicts by ~10% at 2800 Å, giving a mean ratio of 1.11 and a standard deviation of 17% (see Figure 2b). This result was confirmed by examining the data from the GHRS Cycle 5 Long-Term Monitor (Feb. 7, 1996), for which similar offsets were derived.

Table 1: Cycle 4 Echelle-B Observations of μ Col

ROOTNAME (LSA)	EXPTIME	DATE-OBS	Order	Central Wavelength
Z2CX010PT	27.2	04/21/94	18	3122.2
Z2CX010QT	27.2	04/21/94	19	2957.8
Z2CX010RT	27.2	04/21/94	20	2810.0
Z2CX010ST	27.2	04/21/94	21	2676.1
Z2CX010TT	27.2	04/21/94	22	2554.5
Z2CX010UT	27.2	04/21/94	23	2443.4
Z2CX010VT	27.2	04/21/94	24	2341.6
Z2CX010WT	27.2	04/21/94	25	2248.0
Z2CX010XT	27.2	04/21/94	26	2161.5
Z2CX010YT	27.2	04/21/94	27	2081.5
Z2CX010ZT	27.2	04/21/94	28	2007.1
Z2CX0110T	27.2	04/21/94	29	1937.9
Z2CX0111T	27.2	04/21/94	30	1873.3
Z2CX0112T	27.2	04/21/94	31	1812.9
Z2CX0113T	27.2	04/21/94	32	1756.2
Z2CX0114T	27.2	04/21/94	33	1703.0

Table 2: Calibration Switch Settings

SWITCH	SETTING	SWITCH	SETTING	SWITCH	SETTING
DQI_CORR	PERFORM	VIG_CORR	PERFORM	BCK_CORR	OMIT
EXP_CORR	PERFORM	MER_CORR	PERFORM	IAC_CORR	PERFORM
DIO_CORR	PERFORM	ADC_CORR	PERFORM	ECH_CORR	PERFORM
PPC_CORR	PERFORM	MDF_CORR	OMIT	FLX_CORR	PERFORM
MAP_CORR	PERFORM	MNF_CORR	OMIT	HEL_CORR	PERFORM
DOP_CORR	OMIT	BMD_CORR	OMIT	VAC_CORR	OMIT
PHC_CORR	PERFORM	PLY_CORR	PERFORM	GWC_CORR	PERFORM

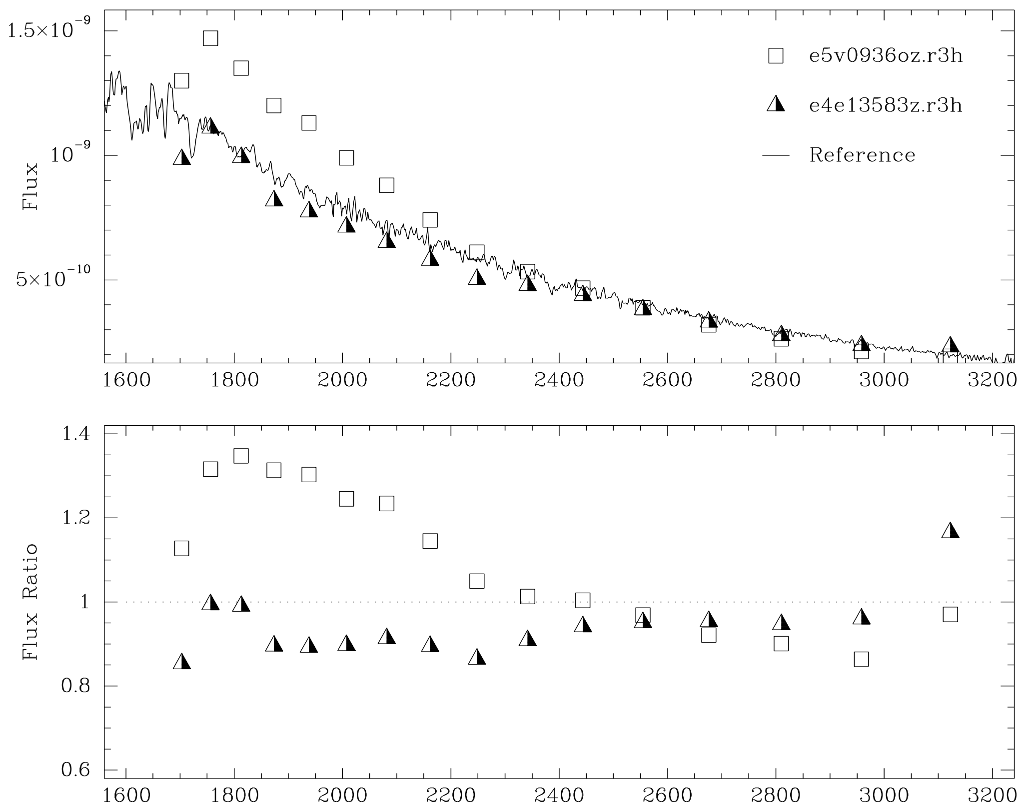

Figure 2: The reference flux for μ Col is plotted with the calculated values from Echelle-B. *a)* The Cycle 4 observations derived using the recommended sensitivity function (boxes) and the previous sensitivity function (triangles) are overplotted on the reference spectrum. *b)* The flux ratio shows the extent of the deviations for each file.

These large discrepancies led us back to examine the previous post-COSTAR sensitivity function (e4e13583z.r3h). This older sensitivity file gave much better results than the one recommended by the CDBS, although not as good as we had hoped. The mean flux ratio became 0.94 with a standard deviation of 7%. In light of these large differences, we decided to start from scratch and completely redetermine the sensitivity function for the Echelle-B grating, for both the LSA and SSA apertures.

The Cycle 4 observations were thus redirected through the pipeline, but now with the switch FLX_CORR set to OMIT. Statistics were again taken over the entire bandpass for each data point, but this time the units were in counts sec^{-1}. The average count rate over the band was again divided by the μ Col fluxes for the same range of wavelengths, and then fit with a cubic spline using the STSDAS fitting task `gfit`. This function defines the new LSA sensitivity.

SSA Sensitivity

Determining the sensitivity for the SSA is not as straightforward, since the amount of light detected depends on how well the object is centered in the aperture. It is therefore useful to examine the SSA/LSA ratio and then multiply the baseline LSA sensitivity curve by this ratio to determine the SSA sensitivity. This ratio was derived for the e5v0936oz.r3h file and is illustrated by the dashed line in Figure 3. The reason for the discontinuous slope is not understood and further confirms our suspicion of the inaccuracy of this file. The SSA/LSA ratio for previous sensitivity, e4e13583z.r3h, is also given in the plot. Because its slope is continuous, and because this ratio is very close to what we had determined for G140M at 1600 Å, we adopt this second ratio.

The resulting SSA sensitivity is thus derived by multiplying the previously determined LSA function by this ratio. The degree of change in the new sensitivity functions is illustrated in Figure 4 where we plot the LSA and SSA curves determined here with the recommended sensitivity file, e5v0936oz.r3h. Note the large changes, not only in the amplitude of the curves, but also in their shape.

When the data are recalibrated with these new sensitivity files, results improve dramatically (Figure 5). Not only does the observed flux lie directly over that of the standard star, mean flux ratio improves to 0.996 with a standard deviation of only 1.4%. These new Echelle-B sensitivity curves have been installed in the CDBS and should be used for any data taken after Feb 4, 1994.

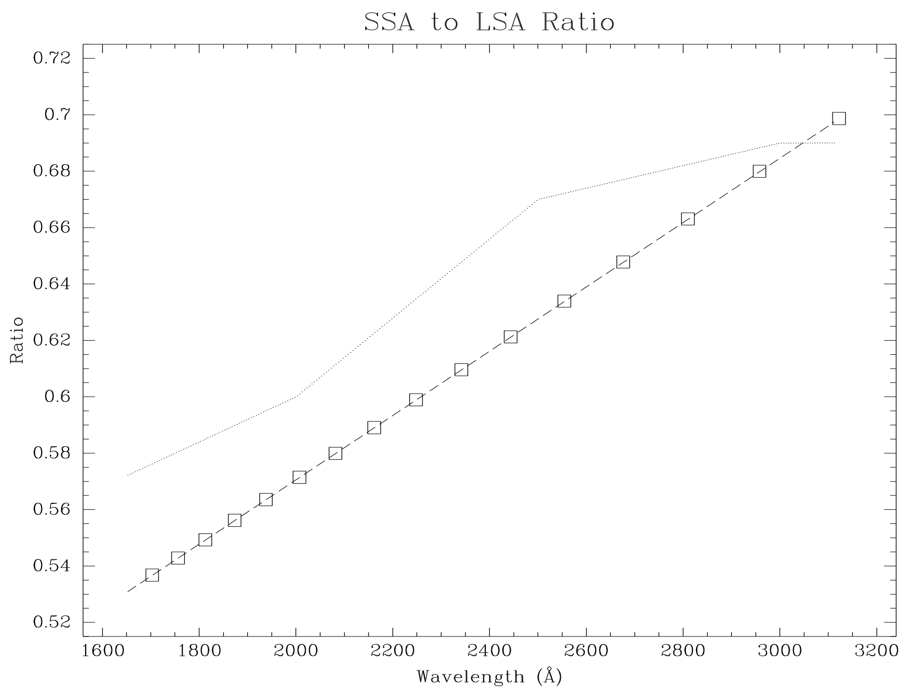

Figure 3: The SSA/LSA ratio is plotted for each of the POST-COSTAR sensitivity functions (e5v0936oz.r3h=dotted line, e4e13583z.r3h=box+dashed line). We adopt the later for our determination of the SSA sensitivity.

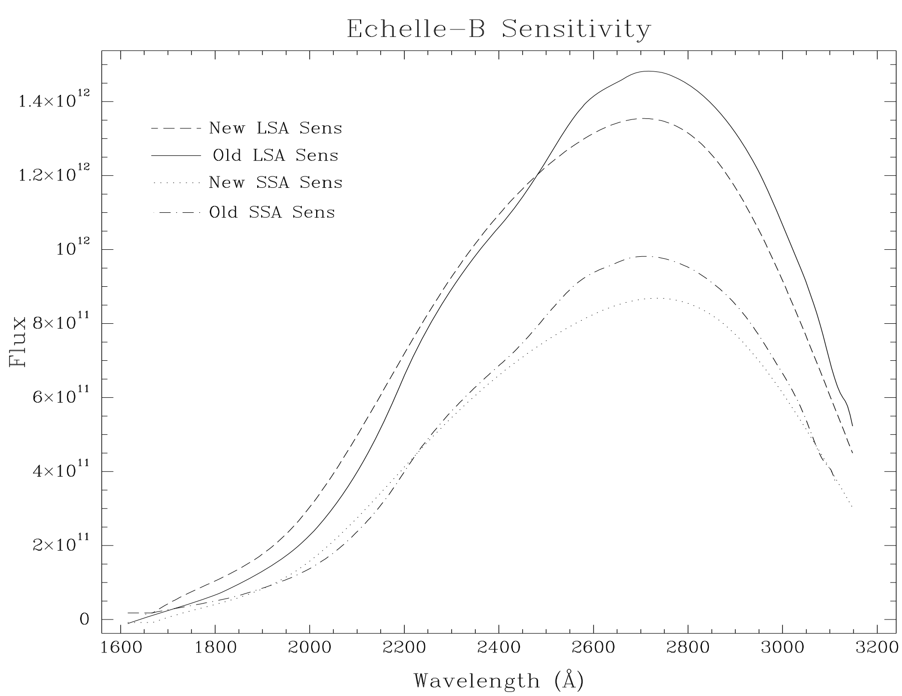

Figure 4: The previous sensitivity functions are plotted with the corrected curves, illustrating the extent of the change required to match the Echelle-B data with the reference spectrum of μ Col.

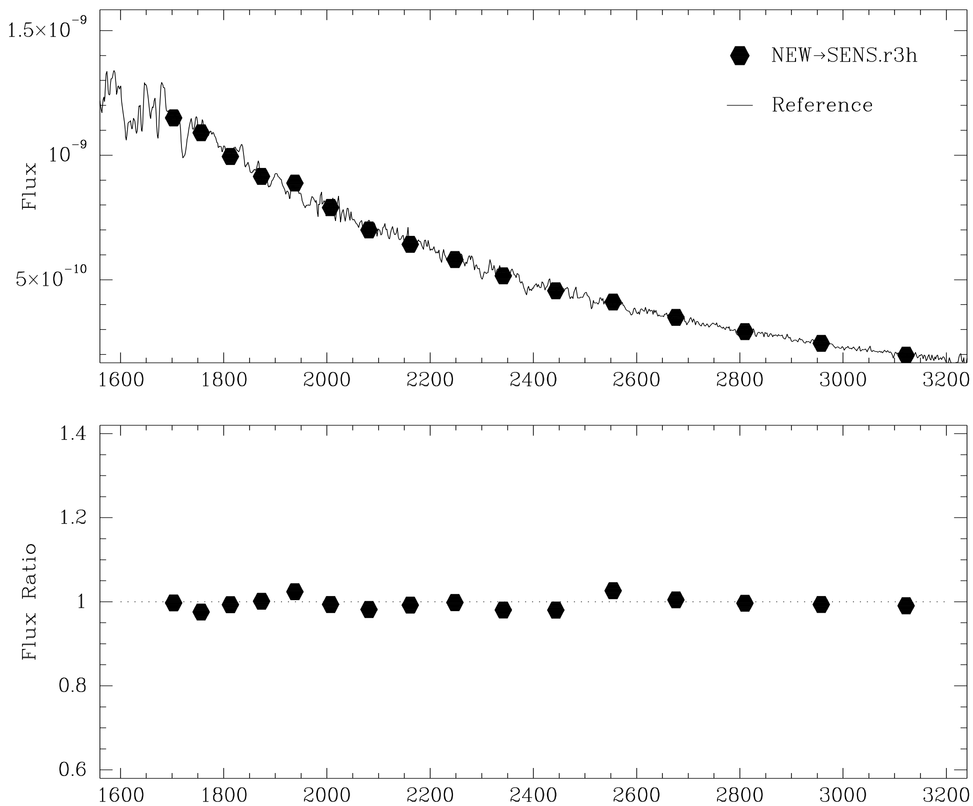

Figure 5: *a)* The reference flux for μ Col is plotted with the recalibrated values from Echelle-B, using the new sensitivity function. *b)* The flux ratio improves dramatically, from a standard deviation of 17% down to only 1.4%

4. Conclusion

We have redetermined the sensitivity files for GHRS grating Echelle-B. Examination of the flux ratios using the recommended sensitivity file (e5v0936oz.r3h) show extremely large deviations. The previous sensitivity function (e5v0936oz.r3h) also proves inaccurate, though errors are not as extreme. Because of these large differences, we have rederived the LSA sensitivity from scratch, ratioing the average count rate with the expected flux from the reference star. Because SSA intensities are so sensitive to centering within the aperture, the new SSA sensitivity function is determined by taking this derived LSA curve and multiplying by the SSA/LSA ratio. These new curves bring the observations into excellent agreement with that of the reference spectrum.