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Updates to the COS/NUV Dispersion Solution Zero-points

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ABSTRACT

After the Cosmic Origins Spectrograph (COS) was installed in 2009 during Servicing Mission 4, a special calibration program (11474) was executed to update the zero points of the dispersion solutions for the NUV channel. Data obtained in this program were used to update the zero-points of 76 out of 102 settings of the G225M, G285M, and G230L gratings. In order to update the zero-points of 21 of the remaining settings, as well as all of the zero points of the G185M grating, three special calibration programs were executed during Summer 2016. These three calibration programs obtained data with COS (PID 14503) and STIS (PID 14504 & 14505). Here we report on the analysis performed on these data to determine the updates to the NUV zero-points. A new NUV wavelength dispersion reference file was delivered to CRDS in February 2017 as a result of this effort.

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1. Introduction

During COS commissioning activities, data were obtained to place the dispersion solutions derived from ground testing data into the on-orbit reference frame (see Oliveira et al. 2010, ISR 2010-05). Due to several issues encountered (inadequate overlap between COS and STIS data used for reference, inadequate target observed for G185M, low S/N of the wavecal, and low S/N of the COS data–see Oliveira et al. 2010, ISR 2010-05), the wavelength dispersion solution zero-points for only 76 out of the total 147 NUV settings were updated to on-orbit values. Given the large number of NUV modes and low usage of the COS NUV channel, we were only alerted to the possible issue with the zero-points when a PI contacted us in early 2016. As a result, in the Summer 2016 three special calibration programs were executed to update the remaining 66 NUV zero-points. The zero-points of stripe C of the G230L grating (cenwaves 2635, 2950, 3000, 3360) were never updated due to the presence of second order light. G230L/2635/NUVA was also never updated due to the low sensitivity of the detector in that region. These programs are described in Section 2. All updated cenwave/stripe combinations are listed in Table 1.

The COS NUV dispersion relations are second order polynomials which assign wavelengths based on the corrected pixel position (corrected for thermal, geometrical, and drift effects). Each cenwave and stripe has a different dispersion relation found inside the dispersion reference file, DISPTAB. The DISPTAB, for each cenwave and stripe, contains: d_{TV03}, the offset between the Wavelength Calibration Aperture (WCA) to the Primary Science Aperture (PSA) as it was measured in Thermal Vaccum 2003 data, *d*, the on-orbit zero-point, or difference between the WCA and PSA, and the dispersion coefficients, a_0, a_1, and a_2. Equations 1 through 4 describe the use of these variables in the COS/NUV dispersion solution.

$$\lambda = a_0 + a_1 x_{prime} + a_2 x_{prime}^2 \tag{1}$$

where

$$x_{prime} = x_{full} + d_{psa} \tag{2}$$

and

$$d_{psa} = d_{TV03} - d \tag{3}$$

giving us a final form of:

$$\lambda = a_0 + a_1(x_{full} + (d_{TV03} - d)) + a_2(x_{full} + (d_{TV03} - d))^2. \tag{4}$$

In early 2016, a temporary DISPTAB was delivered in which the on-orbit zero-point (*d* values) from the closest stripes were adopted as preliminary on-orbit zero-

Table 1. COS cenwaves and stripes for which the dispersion zero-points needed to be updated. The target used to determine each zero-point is included as well as the associated STIS grating for the reference data used in our analysis. G230L 3360/NUVB has no overlapping STIS data.

COS Grating	Cenwave	Stripes Updated	Target	STIS Grating	COS PID	STIS PID
G185M	1786	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1817	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1835	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1850	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1864	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1882	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1890	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1900	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1913	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1921	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1941	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1953	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1971	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	1986	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
	2010	NUVA, NUVB, NUVC	NGC330-B37	E230M	14503	9116
G225M	2186	NUVA, NUVB	HD187691	E230M	11474	14504
	2217	NUVA, NUVB	HD187691	E230M	11474	14504
	2233	NUVA, NUVB	HD187691	E230M	11474	14504
	2250	NUVA, NUVB	HD187691	E230M	11474	14504
	2268	NUVA	HD187691	E230M	11474	14504
	2283	NUVA	HD187691	E230M	11474	14504
	2306	NUVA	HD187691	E230M	11474	14504
	2325	NUVA	HD187691	E230M	11474	14504
	2339	NUVA	HD187691	E230M	11474	14504
G285M	2996	NUVC	HD6655	G230MB	11474	14505
	3035	NUVC	HD187691	G430M	11474	14504
	3057	NUVC	HD187691	G430M	11474	14504
	3074	NUVC	HD187691	G430M	11474	14504
	3094	NUVC	HD187691	G430M	11474	14504
G230L	2950	NUVA	HD6655	G230M	11474	14505
	3000	NUVA	HD6655	G230M	11474	14505
	3360	NUVB	HD6655	N/A	11474	N/A

points where updates were needed. A STAN[1] was released in June 2016 explaining these updates. While this improved the wavelength calibration of COS NUV data, the COS team believed we could get an even more accurate solution by observing targets for which we already had overlapping data either with COS or STIS. This is described in further detail in Section 2.

In this ISR we describe in detail the updates made to the temporary DISPTAB (05d1514fl_disp.fits) to create the updated DISPTAB (12e1345gl_disp.fits) and the analysis undertaken to derive the updated zero-points. Section 2 contains a description of the special calibration programs designed to update the zero-points, Section 3 briefly describes the cross-correlation analysis we used to derive the zero-point offsets between the COS and STIS data, and Section 4 presents our results. The full list of the settings that were updated, as well as the updated values, can be found in Appendix A.

2. Observations

In Spring 2016, three special calibration programs were executed–14503, 14504, and 14505– for the purpose of calculating the zero-points for the settings listed in Table 1.

Program 14503 (*Constraining the zero-points of the COS/NUV wavelength solution - G185M*, PI: Sonnentrucker) obtained COS data with all G185M cenwaves to observe the external target NGC330-B37. These data were combined with existing archival STIS E230M data from program 9116 to derive new G185M zero-points.

Program 14504 (*Constraining the zero-points of the COS/NUV wavelength solution - G225M and G285M*, PI: Roman-Duval) obtained data with the STIS E230M and G430M gratings to observe a radial velocity standard star, HD187691 with v_{rad} = 0.0 $\pm$ 0.3 km/s (Oliveira et al. 2010). Existing COS data from program 11474 were used along with this newly obtained STIS data to derive the new zero-points for the G285M settings–with the exception of 2996/NUVC–and G225M settings listed in Table 1.

Lastly, in program 14505 (*STIS data of HD6655 to derive COS G285M/G230L wavelength zero-points*, PI: Oliveira) we observed another velocity standard star, HD6655, with v_{rad} = 19.5 $\pm$ 0.3 km/s (Oliveira et al. 2010) with the STIS G230MB and G230M gratings. Data from this program and COS data from program 11474 were used to update the zero-points for the G230L settings listed in Table 1–with the exception of the 3360/NUVB setting–as well as the G285M 2996/NUVC setting. The G230L 3360/NUVB setting was updated using COS G285M 3094/NUVB observations of HD187691. See Section 4.4 for more details.

[1]The COS June 2016 STAN which explains the temporary DISPTAB that was delivered is found at: www.stsci.edu/hst/cos/documents/newsletters/cos_newsletters/full_stories/2016_06/new_reference_files

3. Data Analysis

The updated zero points were derived from a cross-correlation between COS and STIS spectra (with the STIS spectra used as a reference wavelength scale) where possible, and between a different cenwave COS spectra in the absence of reference STIS data. Throughout this analysis, we use STIS as a reference spectrum when possible because of its high wavelength accuracy. The absolute wavelength accuracy of the STIS CCD is $\pm$0.5 pixels. For the G230MB grating this translates to 0.075 Å, and for the G430M grating this is 0.14 Å. The STIS MAMA has an absolute wavelength accuracy of $\pm$1.0 pixel. For the E230M echelle grating, this translates to 0.03 Å. For the G230M grating, this is an accuracy of 0.09 Å. More information about the wavelength accuracy of the STIS detectors can be found in Section 16.1 of the STIS instrument handbook and Section 4.32 of the STIS data handbook. This level of accuracy in the wavelength calibration allows us to confidently use STIS as a reference spectrum in our analysis to obtain an accuracy for the COS NUV of 15 km/s (0.17 Å) for the M-gratings, except G185M which has an improved accuracy of 30 km/s (0.3 Å), and 175 km/s (1.8 Å) for G230L.

In the updated DISPTAB (12e1345gl_disp.fits), the second order, a_2, terms are on the order of 10^{-7}, and the variation of d between stripes of the same cenwave is small (see Oliveira et al. 2010). Because of this we chose to leave the d values unchanged and to instead fold in the zero-point updates in the constant term (a_0) in the dispersion solution (Equation 4). To find these new on-orbit zero-point differences we cross-correlated the COS NUV data to the STIS data, using STIS as the reference. The cross-correlation gave us a shift value corresponding to the offset between the COS and STIS spectra in Angstroms. This shift can be converted to pixels by multiplying by the linear dispersion value (a_1), but all calculations to the final values in the DISPTAB were done in Angstroms. Appendix A lists of all of the shift values that were found for the NUV settings that were updated.

While the cross-correlation routine used for this is fundamentally the same as that used for the FUV wavelength calibration updates (see Plesha et. al. TIR in prep), there were some differences. The first difference was the size of the slice of the NUV spectrum we used in the cross-correlation. Because each NUV stripe's wavelength range is on the order of 80 Å and the targets used were non-variable targets, the entire stripe was utilized in the cross-correlation rather than slicing the spectrum into specified windows, as was done in the FUV. Note that due to the presence of edge effects in the NUV stripes, 200 pixels were excluded on either side of each stripe before performing the cross-correlation.

Another major difference, relative to the FUV analysis, was that the COS and STIS data were convolved in order to compare the spectra at similar resolutions. The STIS G230M data were convolved with a Gaussian with a standard deviation of 3 (σ=3), which controls the width, to get them at the same resolution as the COS G230L data. The COS G285M data were convolved with a Gaussian with σ=2 to match it to the STIS G430M resolution. The STIS E230M data were convolved with the COS NUV

Table 2. Summary of the convolution and binning used for all data. The "Data to be Changed" column indicates the instrument and grating of the data that the convolution and binning was applied to. The "Matched Resolution to" column indicates the instrument and grating for which the data are being cross-correlated to. The Gaussian distributions were defined using standard deviations (σ) to indicate different widths.

Data to be Changed	Convolved With	Binned By	Matched Resolution to
STIS G230M	Gaussian (σ=3)	None	COS G230L
COS G285M	Gaussian (σ=2)	3 pix	STIS G430M
STIS E230M	COS NUV LSF	None	COS G185M / G225M
COS G285M/3094	Gaussian (σ=8)	None	COS G230L 3360/NUVB

line spread function (LSF)[2] centered at 2100 angstroms to match the COS G185M and G225M data. Finally, the COS G285M/3094 data were convolved with a Gaussian with σ=8 to match the G230L/3360/NUVB data. A Gaussian was used for G230L instead of an LSF due to lack of availability of a low resolution COS LSF. These convolutions are summarized in Table 2

To increase the S/N in the COS G285M data (correlated to slightly higher resolution reference STIS G430M data) and optimize the cross-correlation analysis, the convolved COS G285M data was binned by 3 pixels (one resolution element). Figure 1 shows that for cenwaves 3057, 3074, 3094 there are not well defined features, and the S/N is low, which is why the binning is needed for this specific grating. No binning was applied to the other data considered here.

In order to test the new zero-points, an internal consistency test was performed. The COS data described in Section 2 was calibrated with the newly derived zero-points and the cross-correlation against STIS data was run again. Because the shifts found in the original cross-correlation went into the new DISPTAB, the cross-correlation performed with the updated data should result in offsets close to zero if the correct zero-points were applied. The results of this test are discussed in Section 4.

Further testing was needed using data outside of what is described in Section 2. Because of the low usage of these settings, there was not a wide selection of data that could be used for this testing. Data from program 13846 was calibrated with the new zero-points and passed to the PI of the program to verify using known redshifts and Lyman series features seen in the spectra. Through private communication with the PI of program 13846, we were able to conclude that the new DISPTAB was a significant improvement for the updated G185M and G225M settings.

[2]LSF found at: http://www.stsci.edu/hst/cos/performance/spectral_resolution/nuv_model_lsf

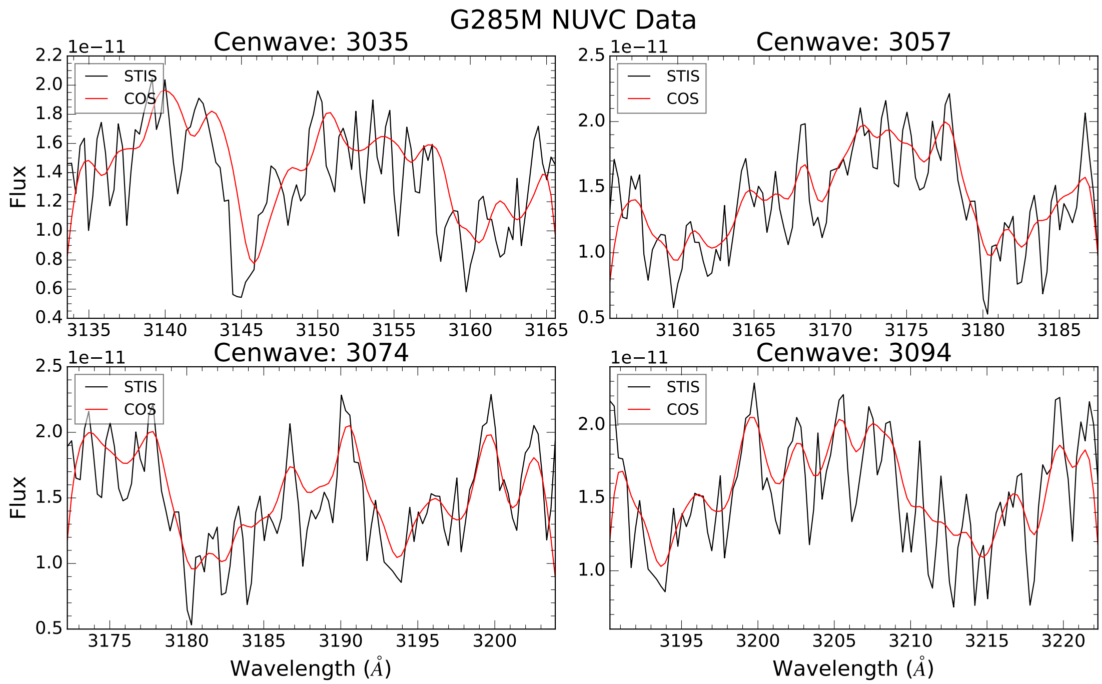

Figure 1. This figure shows the STIS G430M data (black) and COS G285M NUVC data calibrated with the temporary DISPTAB (red) for each of the cenwaves that used HD187691 data. With the exception of the 3035 cenwave, the features aren't well defined, and the S/N of the data is low. To try to improve this, the COS data are binned by a resolution element (3 pixels) and convolved with a 3 pixel gaussian to put the data on the same resolution scale as the slightly lower resolution of the STIS data.

4. Results

Using the above data and techniques, we derived new a_0 values for the G225M, G285M, G230L, and G185M COS NUV gratings. Appendix A lists the temporary DISPTAB (05d1514fl_disp.fits) a_0 values in Å, the updated DISPTAB (12e1345gl_disp.fits) a_0 values in Å, and the difference between these two values in Å and in pixels. The difference between the two are the shifts found by the cross-correlation between the COS exposures and the STIS exposures. Using these new a_0 values, we recalibrated the COS data used during the analysis and performed the cross-correlation once more. Shown in Figures 2 through 10 are the residuals from the cross-correlation between COS and STIS with the temporary DISPTAB values (filled circles) and the new DISPTAB values (filled stars). The results are broken down by grating.

4.1 G285M Results

The G285M grating shifts were within ± 1 pixel, except for the 3094 cenwave as shown in Figure 2. The 3094 cenwave had shallow features and lower S/N ratio compared to the other cenwaves in the G285M grating, as shown in Figure 1, which led to a higher error of ± 3 pixels. This is still within one resolution element on the COS NUV detector, and is improved from the previous ± 6 pixel error.[3]

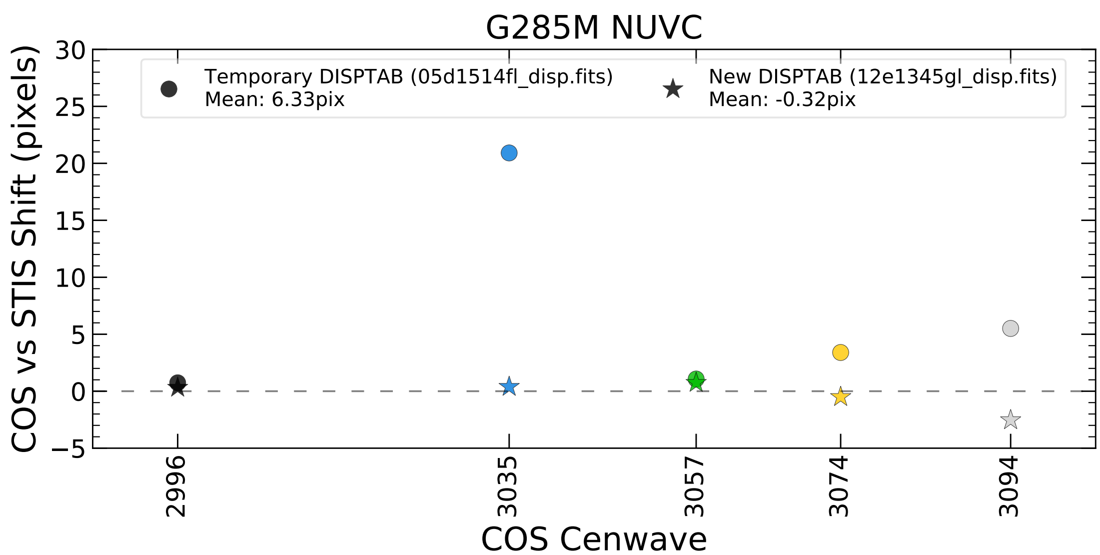

Figure 2. This figure shows the improvement of the zero-points for the G285M NUVC settings. Each color represents a different cenwave. A cross-correlation was performed between the COS and STIS spectra calibrated with the temporary DISPTAB (circles) and the new DISPTAB updated with new zero-points (stars).

[3] The G285M grating hasn't been used outside of calibration monitoring since 2010, and the COS data we used was from 2009.

4.2 G185M Results

For the G185M grating, our analysis showed that the initial zero-point values in the temporary DISPTAB were already within our accuracy goal of ±3 pixels, so the improvement to ± 1 pixel is a lot less drastic than in the other NUV gratings.

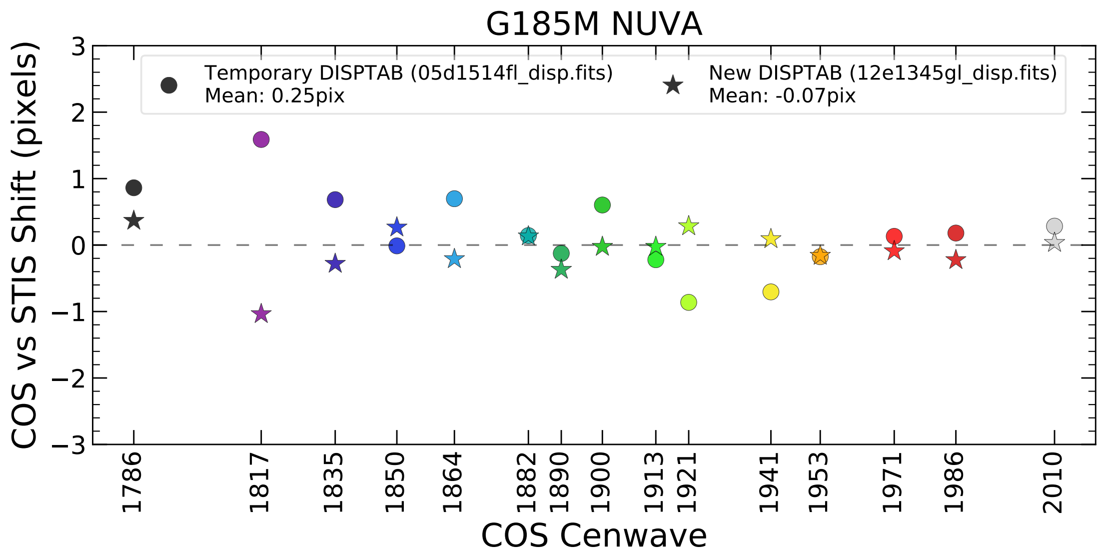

Figure 3. Same as Figure 2, but for the G185M NUVA settings.

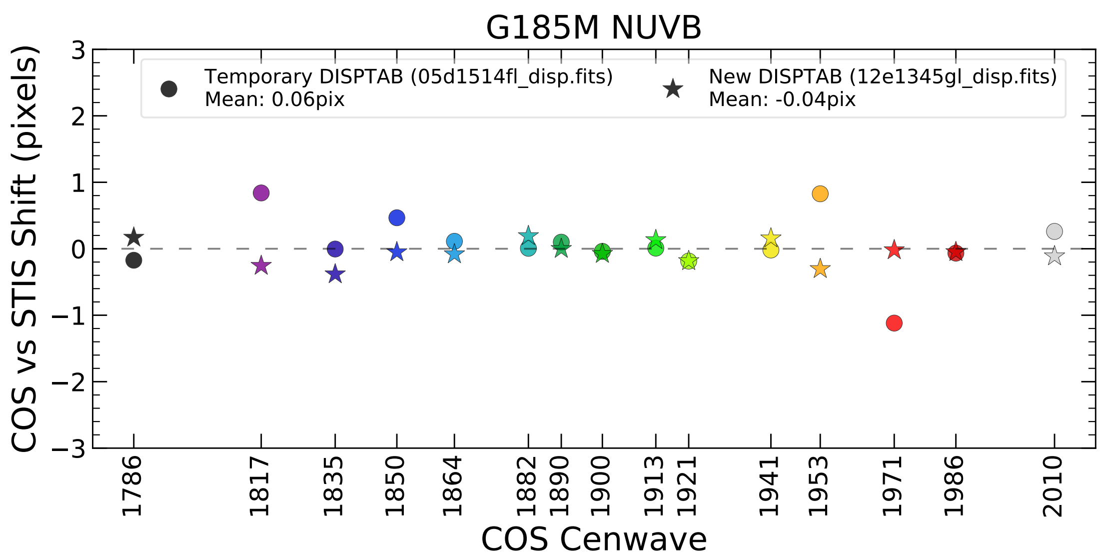

Figure 4. Same as Figure 2, but for the G185M NUVB settings.

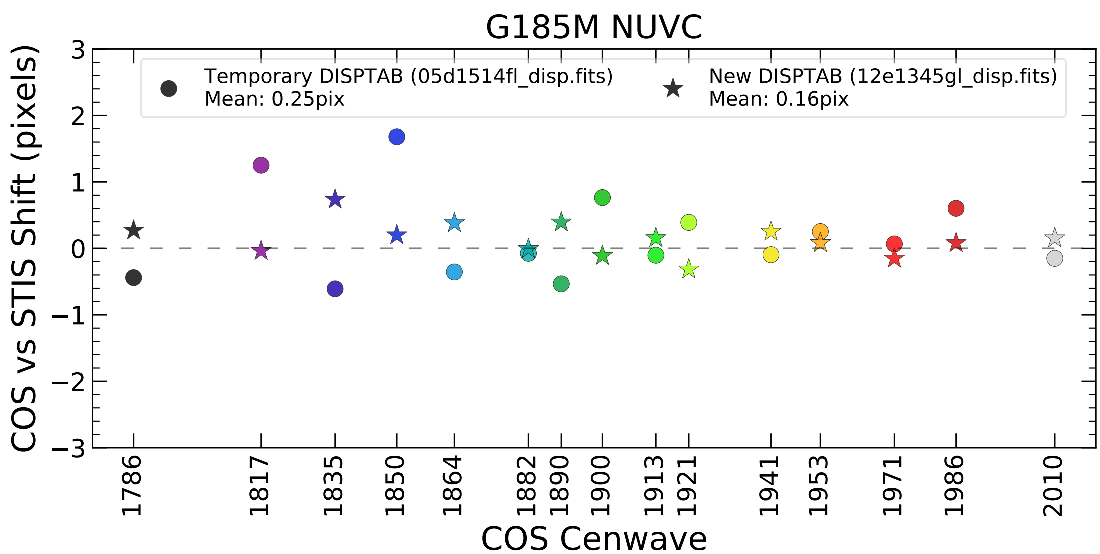

Figure 5. Same as Figure 2, but for the G185M NUVC settings.

4.3 G225M Results

The G225M grating showed the smallest error out of all the gratings due to the use of the STIS E230M grating as a reference. The residual zero-points offsets measured with the recalibrated data are well within ±1 pixel when compared to STIS, which is a vast improvement over the ±8 pixels previously measured as shown in Figures 6 and 7.

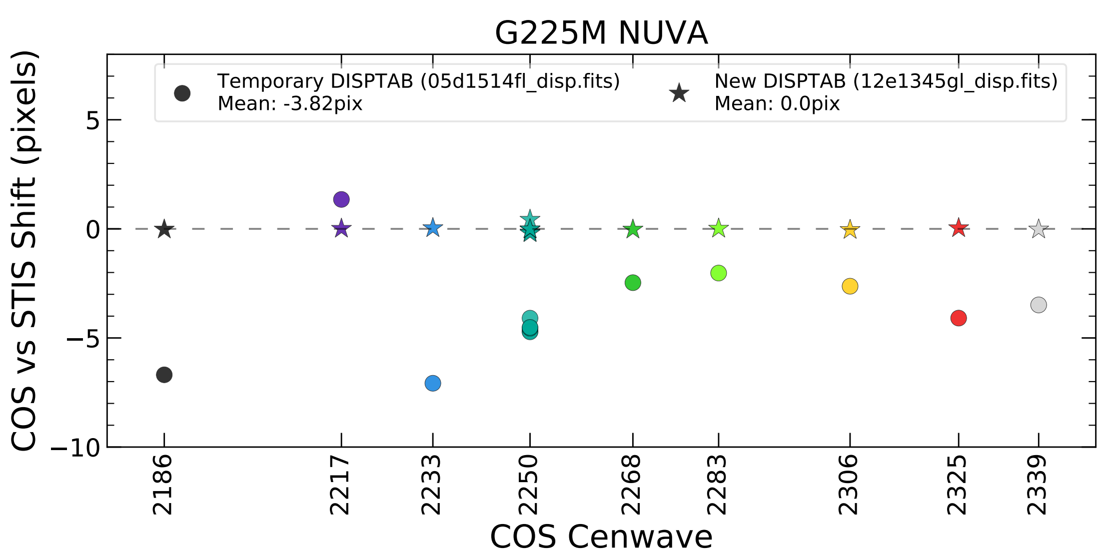

Figure 6. Same as Figure 2, but for the G225M NUVA settings. The 2250 cenwave has multiple data points due to using multiple test datasets which were available.

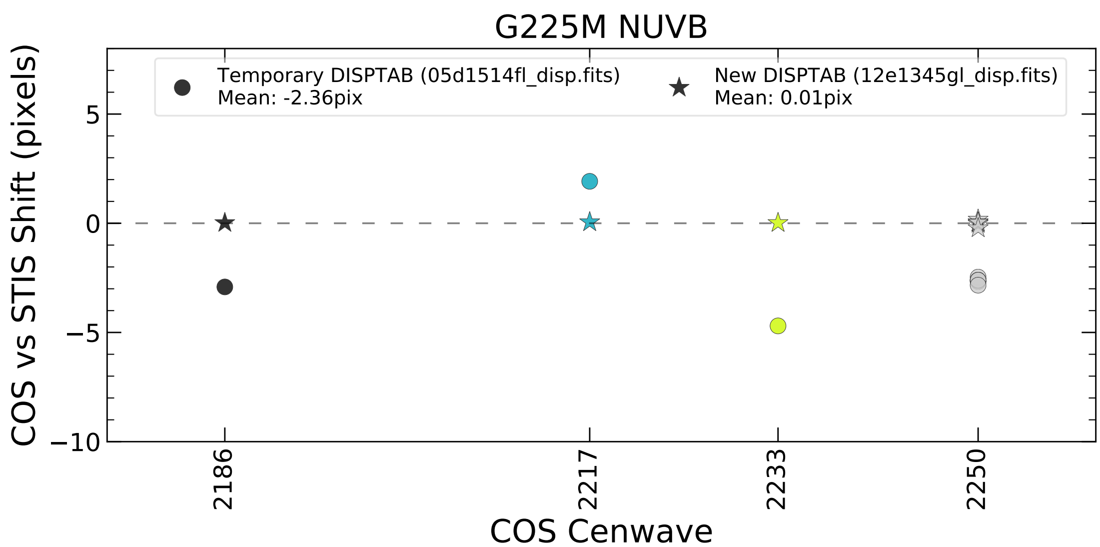

Figure 7. Same as Figure 2, but for the G225M NUVB settings. The 2250 cenwave has multiple data points due to using multiple test datasets which were available.

4.4 G230L Results

The recalibrated G230L/NUVA settings when cross-correlated to STIS also produced a shift of within ±1 pixel as shown in Figure 8.

However, the G230L 3360/NUVB setting had to be analyzed separately because the STIS G430M data did not overlap with any spectral feature that could be used in the cross-correlation. Instead, we used an overlapping COS setting with a different standard star. We chose to use G285M 3094/NUVC data of HD187691 shifted by 0.208Å (19.5 km/s at 3200Å) into the HD6655 reference frame and updated with the new dispersion zero-point. We were then able to cross-correlate the overlapping regions of the two stripes to get an approximation of the a_0 value. Figure 9 shows that using this method still produced a valid zero-point shift to use in the new dispersion reference file.

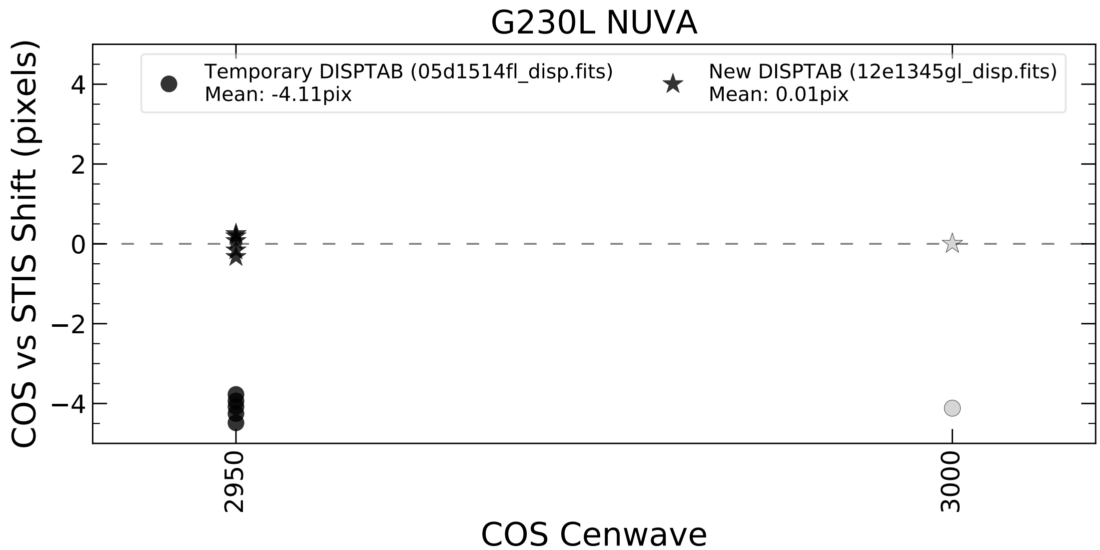

Figure 8. Same as Figure 2, but for the G230L NUVA settings. The 2950 cenwave has multiple data points due to using multiple test datasets which were available

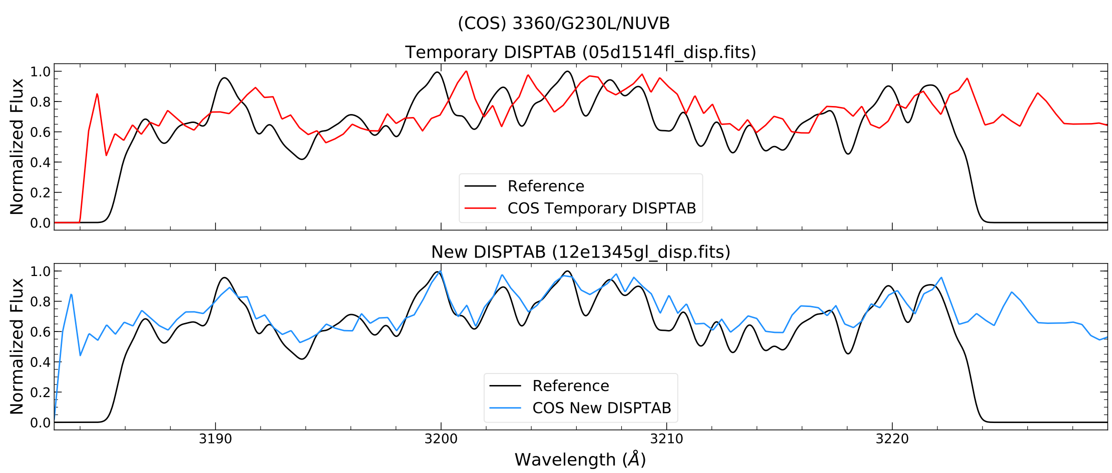

Figure 9. This figure shows we are still able to determine a zero-point for COS G230L 3360/NUVB despite having no overlapping COS and STIS data of the same target. Top: In black is the COS G285M 3094/NUVC data of HD187691, shifted by 0.208Å to account for the radial velocity difference between HD187691 and HD6655. In red is the COS G230L 3360/NUVB data calibrated with the old DISPTAB. Bottom: In black is the same G285M 3094/NUVC data, but in blue is the COS G230L 3360/NUVB data calibrated with the new DISPTAB.

Despite having to use COS instead of STIS as a reference, the G230L/NUVB 3360 cenwave still was within ± 2 pixels as seen in Figure 10.

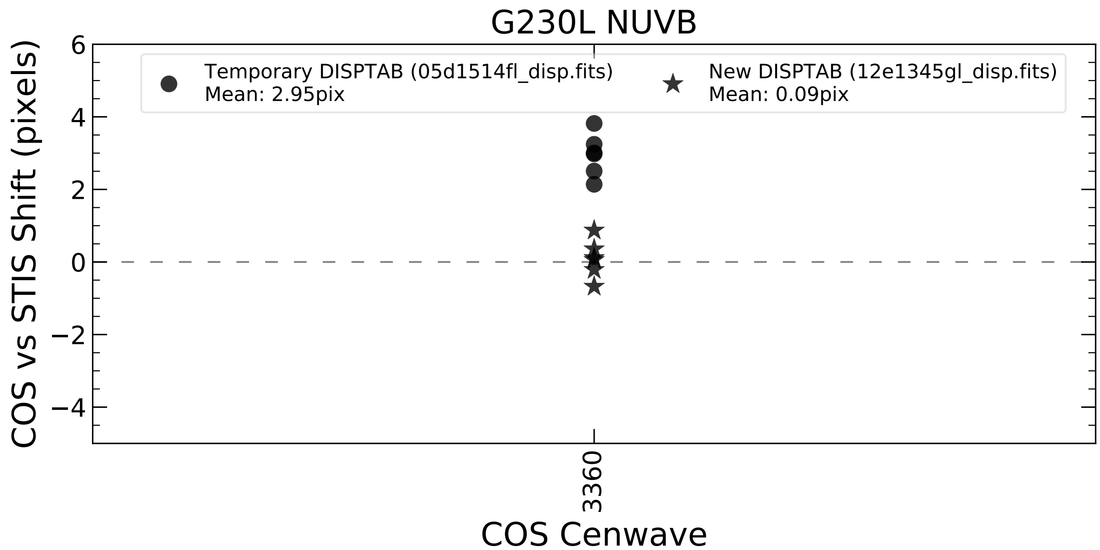

Figure 10. Same as Figure 2, but for the G230L NUVB settings. The 3360 cenwave has multiple data points due to using multiple test datasets which were available

5. Conclusions

Three special calibration programs were executed to obtain COS and STIS data necessary to update the zero-points of the COS/NUV dispersion solution for all COS G185M cenwaves and select cenwaves for the G225M, G285M and G230L gratings. A cross-correlation analysis was used to derive the zero-point updates and a new wavelength dispersion solution reference file, DISPTAB, was delivered in February 2017. The updated zero-points for the COS/NUV settings correspond to a wavelength accuracy of $\sim$5 km/s for G225M, $\sim$10 km/s for G285M, $\sim$6 km/s for G185M, and $\sim$80 km/s for G230L. All of these fall within the quoted accuracies in the COS instrument handbook of 15 km/s for the G225M, G285M, and G185M gratings and 175 km/s for the G230L grating.

References

Fox, A., et al. 2015, COS Data Handbook , Version 3.0, (Baltimore: STScI)
Fox, A., et al. 2017, Cosmic Origins Spectrograph Instrument Handbook , Version 9.0, (Baltimore: STScI)
Oliveira et al, 2010, COS Instrument Science Report 2010-05(v1), “SMOV: COS NUV Wavelength Calibration”
Plesha et al., in prep, COS Technical Instrument Report
Riley, A., et al. 2017, ”Space Telescope Imaging Spectrograph Instrument Handbook”, Version 16.0, (Baltimore: STScI)

Appendix A

Table 3. This table presents the updated zero-point values (a_0) for all modes that were updated as well as the difference between the two in both Angstroms and pixels.

Grating	Cenwave/Stripe	a_0 (Temporary) 05d1514fl_disp.fits	a_0 (Updated) 12e1345gl_disp.fits	Difference (Å) new - temp.	Difference (pixels) new - temp.
G225M	2186 / NUVA	2069.59	2069.83	0.24	6.7
	2186 / NUVB	2168.98	2169.09	0.10	2.9
	2217 / NUVA	2100.78	2100.73	-0.05	-1.4
	2217 / NUVB	2199.70	2199.63	-0.07	-1.9
	2233 / NUVA	2118.07	2118.33	0.26	7.1
	2233 / NUVB	2216.72	2216.88	0.16	4.7
	2250 / NUVA	2135.05	2135.21	0.16	4.5
	2250 / NUVB	2233.42	2233.51	0.09	2.6
	2268 / NUVA	2153.88	2153.97	0.09	2.5
	2283 / NUVA	2169.47	2169.54	0.07	2.0
	2306 / NUVA	2190.32	2190.41	0.09	2.6
	2325 / NUVA	2210.73	2210.87	0.14	4.1
	2339 / NUVA	2224.24	2224.36	0.12	3.5
G285M	2996 / NUVC	3089.91	3089.88	-0.03	-0.7
	3035 / NUVC	3127.66	3126.88	-0.79	-20.9
	3057 / NUVC	3150.33	3150.29	-0.04	-1.1
	3074 / NUVC	3167.17	3167.04	-0.13	-3.4
	3094 / NUVC	3185.36	3185.15	-0.20	-5.5
G230L	2950 / NUVA	1671.33	1672.94	1.61	4.1
	3000 / NUVA	1731.34	1732.94	1.60	4.1
	3360 / NUVB	*3187.43*	*3186.28*	*-1.15*	*-2.9*
G185M	1900/NUVA	1776.983	1776.961	-0.022	-0.59
	1900/NUVB	1880.428	1880.429	0.001	0.04
	1900/NUVC	1985.841	1985.814	-0.028	-0.80
	1817/NUVA	1693.757	1693.698	-0.059	-1.5
	1817/NUVB	1798.225	1798.194	-0.031	-0.84
	1817/NUVC	1904.817	1904.771	-0.046	-1.3
	1850/NUVA	1728.593	1728.593	0.0004	0.01
	1850/NUVB	1832.633	1832.616	-0.017	-0.47
	1850/NUVC	1938.734	1938.672	-0.062	-1.7
	1882/NUVA	1760.314	1760.309	-0.005	-0.14
	1882/NUVB	1863.9779	1863.9777	-0.0003	-0.007
	1882/NUVC	1969.607	1969.610	0.0027	0.08
	1921/NUVA	1799.476	1799.508	0.032	0.85
	1921/NUVB	1902.635	1902.642	0.007	0.19
	1921/NUVC	2007.707	2007.692	-0.014	-0.41
	1953/NUVA	1832.004	1832.011	0.0064	0.17
	1953/NUVB	1934.740	1934.709	-0.031	-0.84
	1953/NUVC	2039.326	2039.316	-0.009	-0.27

Table 3. (cont'd)

Grating	Cenwave/Stripe	a_0 (Temporary) 05d1514fl_disp.fits	a_0 (Updated) 12e1345gl_disp.fits	Difference (Å) new - temp.	Difference (pixels) new - temp.
	1986/NUVA	1866.221	1866.215	-0.007	-0.18
	1986/NUVB	1968.491	1968.494	0.002	0.07
	1986/NUVC	2072.565	2072.543	-0.022	-0.64
	1786/NUVA	1664.269	1664.237	-0.032	-0.84
	1786/NUVB	1769.062	1769.068	0.006	0.17
	1786/NUVC	1876.065	1876.081	0.016	0.45
	1835/NUVA	1712.059	1712.034	-0.025	-0.67
	1835/NUVB	1816.2998	1816.2999	0.0001	0.004
	1835/NUVC	1922.636	1922.659	0.022	0.63
	1864/NUVA	1741.611	1741.585	-0.026	-0.68
	1864/NUVB	1845.494	1845.490	-0.004	-0.11
	1864/NUVC	1951.413	1951.426	0.013	0.37
	1890/NUVA	1769.646	1769.651	0.004	0.12
	1890/NUVB	1873.176	1873.172	-0.004	-0.01
	1890/NUVC	1978.682	1978.702	0.0197	0.56
	1913/NUVA	1791.960	1791.968	0.0081	0.22
	1913/NUVB	1895.2014	1895.2011	-0.0003	-0.009
	1913/NUVC	2000.383	2000.387	0.004	0.11
	1941/NUVA	1819.556	1819.582	0.026	0.70
	1941/NUVB	1922.4346	1922.4353	0.0007	0.02
	1941/NUVC	2027.203	2027.206	0.0035	0.01
	1971/NUVA	1850.016	1850.011	-0.005	-0.13
	1971/NUVB	1952.483	1952.525	0.041	1.1
	1971/NUVC	2056.815	2056.813	-0.002	-0.07
	2010/NUVA	1891.157	1891.147	-0.010	-0.28
	2010/NUVB	1993.111	1993.102	-0.0096	-0.27
	2010/NUVC	2096.768	2096.773	0.005	0.16