SWIFT-UVOT-CALDB-01-R04
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Comments:
Updated zero points for the UVOT UV filters (uvw1,uvm2 and uvw2)

SWIFT UVOT CALDB RELEASE NOTE

SWIFT-UVOT-CALDB-01-R04: Zero Points

1. Summary:

This product defines the in-orbit zero point and zero point error for the 7 lenticular filters of the UVOT.

2. Component Files:

FILE NAME	VALID DATE	RELEASE DATE	VERSION

3. Scope of Document:

This document contains a description of the zero point calibration analysis performed to produce the zero point calibration products for the UVOT calibration database.

4. Changes:

This is the third release of the in-orbit zero points, updating the ultraviolet (UV) zero points, to coincide with the change in effective area curves.

This version (10wa) includes the following changes:

- the zero points have been derived for the uvot instrumental magnitude system by using the revised in-orbit effective area curves (uvot_caldb_effectiveareas_10wa.doc)
- A wider range of standard stars with different colours were used.
- Many more measurements of the original white dwarf standard stars have been used, with corrections for changes in sensitivity with time and position on the detector (LSS).
- An up-to-date spectrum for Vega has been used.

5. Reason For Update:

The zero point calibration has to be updated in common with the effective area curves. The update (to version 03) was undertaken to improve the zero point calibration by increasing the number and colour range of standard stars used, and also by using more observations for each star.

6. Expected Updates:

Further updates may follow with the addition of new observations.

7. Caveat Emptor:

The ground-based zero points were calculating using incorrect ground-based effective area curves. Therefore a comparison between the in-orbit zero points and the ground-based zero points in the original version of the CALDB is meaningless.

Due to the lack of faint spectroscopic standard stars in the UV, the UV and white zero points have been calibrated with few stars.

8. Data Used:

This update only concerns the UV filters. The work done previously is still relevant for the optical and white filters (SWIFT-UVOT-CALDB-01-R03). Observations of 3 faint white dwarf stars and 5 other HST standard stars with known ultraviolet spectra were used for the new UV filter analysis (see Table 1). Where multiple observations were taken, the individual count rate measurements were corrected for positional and time sensitivity variations, and then averaged.

Object name	**Origin**	**Filter**	**Target ID**	**V mag**	**B mag**	**Type**
WD1121+145	IUE	uvw1, uvm2	55250	16.9	16.6	DA D
WD1026+453	CALSPEC	uvw1, uvm2, uvw2	55761	16.1	15.9	DA D
WD1657+343	CALSPEC	uvw1, uvm2, uvw2	55900	16.4	16.2	DA D
LDS749B	CALSPEC	uvw1, uvm2, uvw2	57350	14.67	14.71	DBQ4
HZ4	CALSPEC	uvw1, uvm2, uvw2	57300	14.51	14.6	DA4
MMJ6476	NGSL	uvw1, uvm2, uvw2	57450	10.9	11.5	A7.2:m
P041C	CALSPEC	uvw1	57950	12	12.62	G0V
P330E	CALSPEC	uvw1, uvm2, uvw2	56770	13	13.64	G0V
P177D	CALSPEC	uvw1, uvw2	56760	13.47	14.13	G0V

Table 1 Standard stars used for the UV zero point calculation. The third column lists the filters for which the sources were used. The second column gives the origin of the calibrated spectra. The CALSPEC spectra were obtained from ftp://ftp.stsci.edu/cdbs/current_calspec/; NGSL from http://archive.stsci.edu/prepds/stisngsl/; IUE from Holberg et al. (2003). The spectrum of MMJ6476 has a model atmosphere added below 1700Å.

9. Description of Analysis:

9.1. Obtaining measured and predicted count rates

Count rates for the sources listed in Table 1 were obtained using UVOTSOURCE, for the standard aperture of 5 arcsecs. The background region was in most cases set to an annulus with an inner radius of 55 pixels (27.5 arcsec), and an outer radius of 70 pixels (35 arcsec). All the default corrections were applied and in addition we corrected for LSS and sensitivity changes with time (lssfile = CALDB sensfile = $CALDB/swusenscorr20041120v001.fits). Outlying values were discarded and the rest were averaged, using a weighting depending on the exposure time.

9.2. Obtaining Zero Points for each UV filter

The count rates were then standardised to the updated Vega spectrum (ftp://ftp.stsci.edu/cdbs/current_calspec/alpha_lyr_stis_005.fits). The expected count rate of each observed star ($C_{exp}(i)$) was calculated by convolving the known spectra (see second column in Table 1) of the observed stars with the in-orbit filter effective areas (see SWIFT-UVOT-CALDB-05-R03). In the same way the spectra of Vega was convolved to produce an expected Vega count rate ($C_{exp}(vega)$). The zero points ($Z_{pt}(i)$) for each source in each filter were then calculated using

$$Z_{pt}(i) = M_{vega} + 2.5\log\left(C_{\exp}(vega)\frac{C_{obs}(i)}{C_{\exp}(i)} \right)$$

Where M_{vega} is the standard Vega magnitude for each filter (set to 0.0 for the UVOT system). The final zero point (Z_{pt}) for each filter was calculated by averaging over all the observations in that filter.

9.3. Plots and Tables

Figures 1– 3 show the data used to produce the zero points for the ultraviolet UVOT filters (see previous version of this document for optical and white). The error bars produced in the plots include the Poisson error in the raw observed count rate, and also include the errors associated with the stellar spectra used.

Table 2 shows the latest in-orbit UVOT zero points (as in version 10wa). The RMS error on the average zero point (a measure of the data scatter) and the standard error for each zero point (a measure of the error on the mean) is also given in the table.

The dotted lines on the plots show the RMS of the average. The error bars on the data points (the average is included in Table 2) are comparable to this RMS, showing that there is no significant additional systematic error. The errors on the zero points included in the CALDB file are shown in bold.

Filter	Zero Point	RMS Error	Standard Error	Average Error Bars
v	17.89	0.04	**0.01**	0.03
b	19.11	0.05	**0.02**	0.05
u	18.34	0.06	**0.02**	0.07
uvw1	17.44	0.02	0.01	**0.03**
uvm2	16.85	0.03	0.01	**0.03**
uvw2	17.38	0.03	0.01	**0.03**
white	20.29	0.05	0.02	**0.04**

Table 2 In-orbit non-colour zero points. The recommended errors to use with the zero points are in bold.

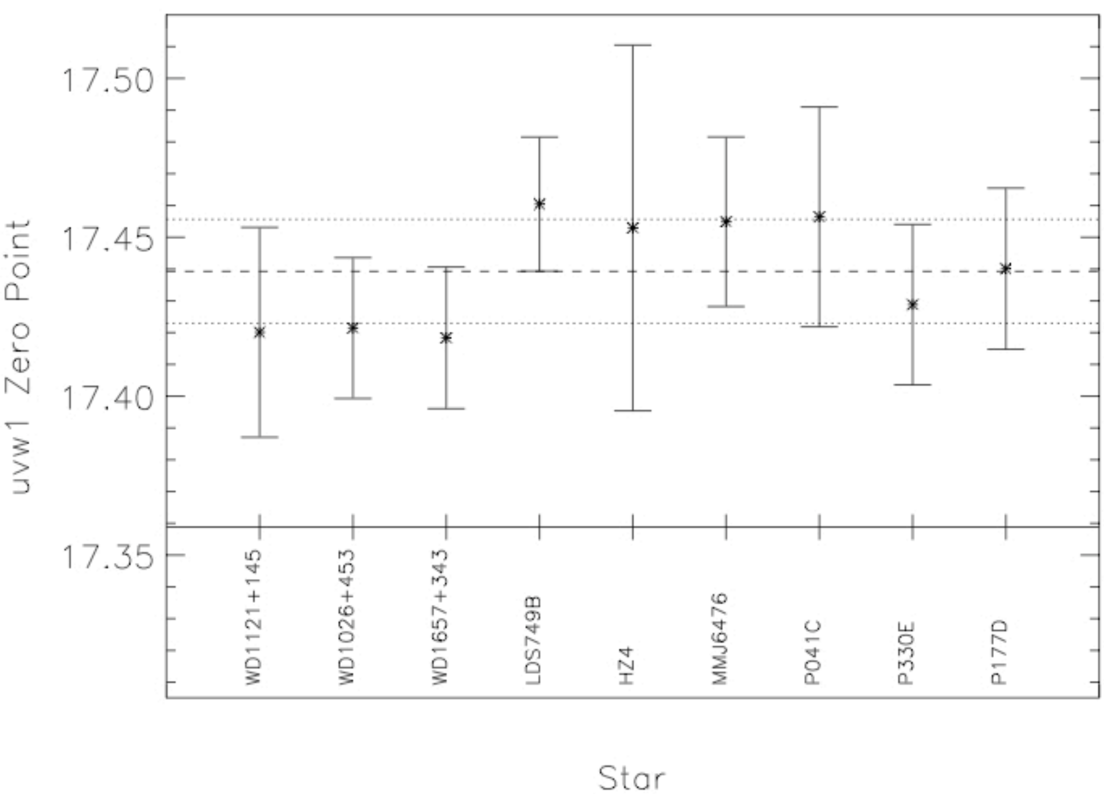

Figure 1. The uvw1 filter zero point data. Each data point represents the zero point as calculated according to the measurement of one standard star. The quoted zero point (in Table 2) is the average of these and is shown with a dashed line. The dotted lines show the RMS.

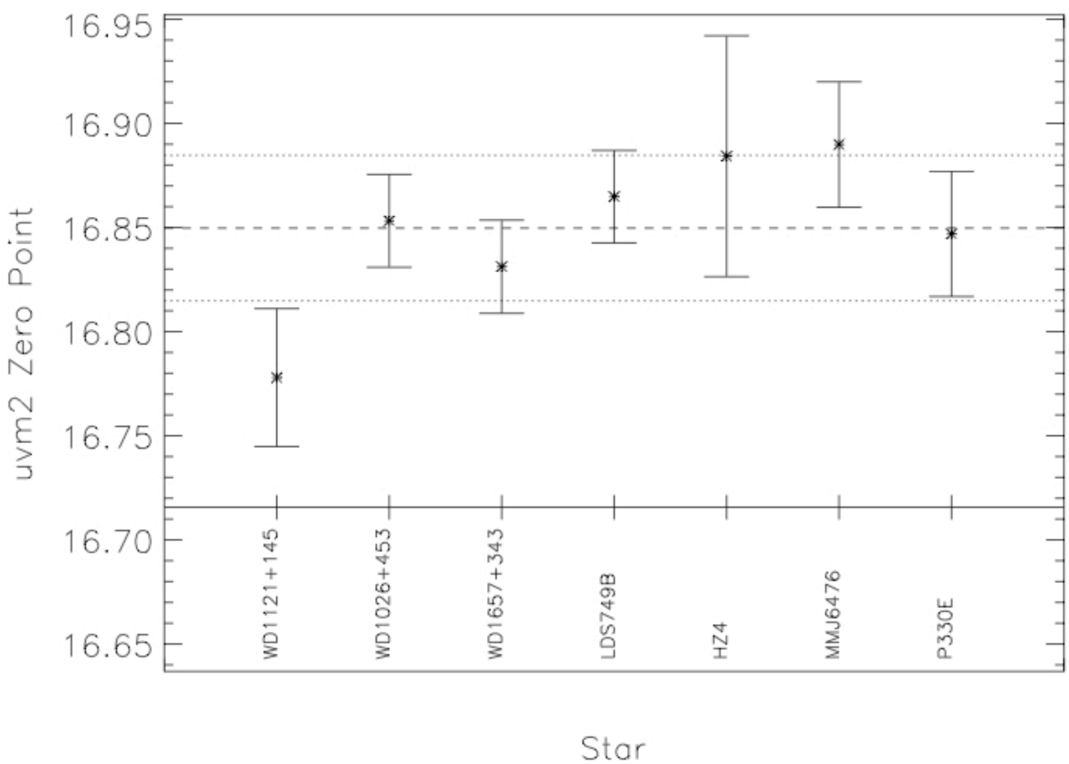

Figure 2. The uvm2 filter zero point data. Each data point represents the zero point as calculated according to the measurement of one standard star. The quoted zero point (in Table 2) is the average of these and is shown with a dashed line. The dotted lines show the RMS.

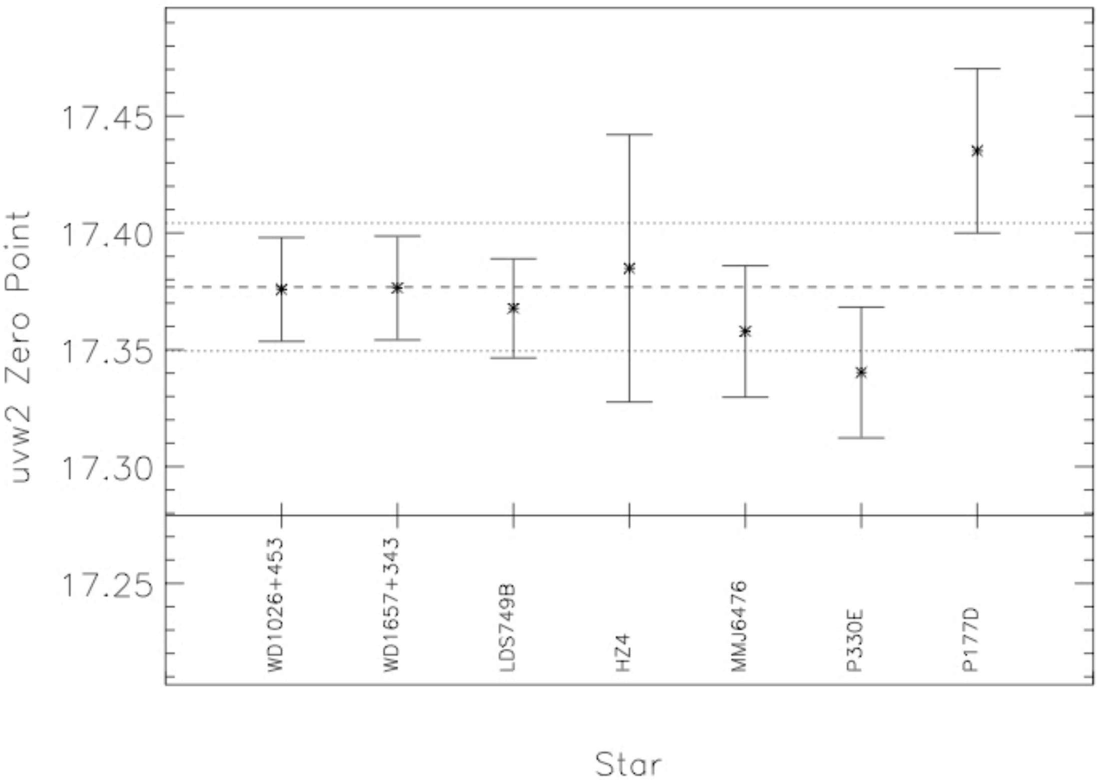

Figure 3. The uvw2 filter zero point data. Each data point represents the zero point as calculated according to the measurement of one standard star. The quoted zero point (in Table 2) is the average of these and is shown with a dashed line. The dotted lines show the RMS.