WFC3 UVIS: Improved Flat Fields

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ABSTRACT
We describe the new improved flat fields for WFC3 UVIS. These corrects for a reflection ghost (the flare) that is present in the previous ground-based flat fields. In addition, photometry of star in the star cluster Omega Centauri taken at different orientations and dither positions are used to correct for the difference in optical path between the ground illumination simulation and the actual HST. The new flat fields typically corrects photometry by 0.006-0.018 mag, depending on filter. The maximum change in photometry is 0.03-0.06 mag. New flat field for all 42 UVIS full frame filters have been used by the STScI pipeline since December 14, 2011.

CREATING THE NEW UVIS FLAT-FIELDS

There are three main components of the UVIS flat-fields:

1. Pixel-to-pixel variations and low frequency structure measured during ground testing by simulating the sky illumination of the UVIS CCD using the optical stimulus CASTLE (Sabbi et al., WFC3-ISR 2008-46).

2. Because of the tilted UVIS focal plane, light is reflected multiple times between the detector and the two chamber windows. This creates a ghost or 'flare' that is imprinted as a wedge-shaped feature in the ground-based flats. The flare strength has its maximum in the upper left corner, ranging from 1.0% in F225W to 2.4% in F850LP. A simplified geometric model of the light reflections has been used to remove the flare from new flats.

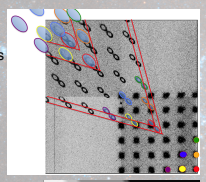

Figure 1. Stars observed at the bottom right of the UVIS CCD are reflected by the two detector windows and causes ghosts in the upper left part of the detector. For a continuum source, the ghost will be wedge-shaped.

Figure 2. Geometric model of the "flare" used to remove the feature from the flat-fields (McCullough, WFC3-ISR 2011-16)

3. Once the flare has been removed from the flats, residual low-frequency structures, which are caused by differences in the ground-based and in-flight optical paths are estimated. This is done using photometry of the globular cluster Omega Centauri, observed at various roll angles and with large dithered steps across the detector, to quantify magnitude differences between measurements for the same stars at different positions on the detector.

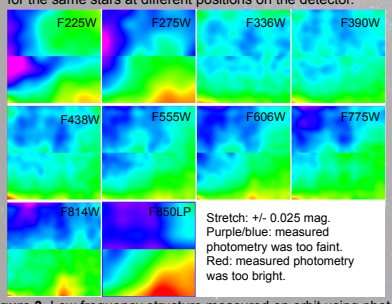

Figure 3. Low frequency structure measured on orbit using photometry of star cluster Omega Centauri for ten filters.

WHICH FILTERS ARE UPDATED?

New flat-fields are created for all 42 full detector filters for WFC3 UVIS. Unique solutions are derived for ten broad-band filters for which calibration data of the star cluster Omega Centauri are available: F225W, F275W, F336W, F390W, F438W, F555W, F606W, F775W, F814W, and F850LP. For the remaining 32 filters, interpolations are used to create new flat-fields. The UVIS quad filters are have not been changed.

HOW WILL PHOTOMETRY BE AFFECTED?

If recalibrating data with the new improved UVIS flat fields, the typical change in photometry for a randomly located object is 0.006-0.018 mag depending on filter. The maximum change is 0.03-0.06 mag per object.

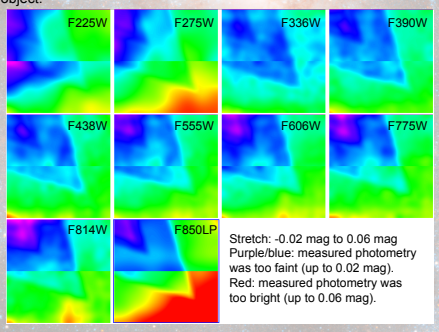

Figure 4. Ratio between the old ground based flat fields and the new improved flat fields illustrating the spatial variations of the corrections. The presence of both the "flare" and low-frequency structure is evident.

Filter	rms	Maximum change single object	Maximum change multiple objects
F225W	0.011 mag	0.030 mag	0.054 mag
F275W	0.013 mag	0.042 mag	0.058 mag
F336W	0.006 mag	0.029 mag	0.039 mag
F390W	0.008 mag	0.034 mag	0.047 mag
F438W	0.008 mag	0.041 mag	0.054 mag
F555W	0.010 mag	0.032 mag	0.049 mag
F606W	0.010 mag	0.036 mag	0.056 mag
F775W	0.010 mag	0.037 mag	0.061 mag
F814W	0.012 mag	0.037 mag	0.061 mag
F850LP	0.018 mag	0.057 mag	0.071 mag

Table 2. Typical change in photometry (rms) when applying the new UVIS flat fields for the ten filters with new independent solutions. The maximum change in the measured photometry for a single object is shown in blue. The maximum relative change in photometry between two or multiple objects in a single image is shown in green.

EXAMPLE OF IMPROVEMENT

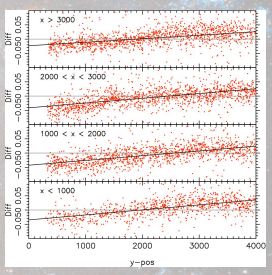

Figure 5. Old F275W flat field

Difference in photometry of ~5400 stars in Omega Centauri for two images rotated 180 degrees as a function of position. In addition to the photometric scatter, there is a bias of >0.05 mag when going across the detector.

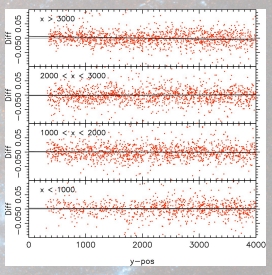

Figure 6. New F275W flat field

The difference in photometry as a function of position, as above. The spatial bias introduced by the old flat field is eliminated.

SUMMARY

- New flat fields are presented for all 42 full frame UVIS filters.
- Typical correction to photometry compared to the previous ground based flat fields is 0.006-0.018 mag, depending on filter. The maximum change in photometry is 0.03-0.06 mag
- Calibrated images retrieved from STScI after August 08, 2011 taken in F336W, F390W, F438W, F555W, F606W, F775W, and F814W have had the new flat fields applied.
- Remaining 35 filters have been applied starting December 14, 2011.
- Flat field images can be obtained at: http://www.stsci.edu/hst/observatory/cdbs/SIfileInfo/WFC3/WFC3PFLbin1UVIS
- More information on the new flat field images is available at: http://www.stsci.edu/hst/wfc3/analysis/uvis_flats