Photometric Aperture Corrections for the ACS/SBC

Roberto J. Avila, Marco Chiaberge

Space Telescope Science Institute, Baltimore MD

Abstract

We present aperture correction tables for the Advanced Camera for Surveys/Solar Blind Channel (ACS/SBC). As part of a campaign to improve the instrument calibrations, we observed the white dwarf J132811.4+463050 using three filters (F125LP, F140LP, F150LP). The observed point spread functions (PSFs) contain more flux in the wings than Tiny Tim models, which can underestimate aperture corrections by as much as ~ 9%, when compared with the observed fluxes. The updated aperture correction tables will be provided to the ReDCaT team so that they can be used in `pysynphot` and HST's Exposure Time Calculator.

Introduction

Several users have reported that both the encircled energy curves published in the instrument handbook and Tiny Tim models (Krist et al., 2011) do not accurately reproduce the observed wings of the SBC PSF (M. Hayes; A. Bostroem, priv. comm.). The documentation for radial profiles and encircled energy curves is spotty; a search of the literature did not uncover any documents providing aperture correction tables that users can refer to. The ACS Instrument Handbook (Avila et al., 2016) contains figures showing radial profiles and encircled energy curves for two filters, F125LP and F150LP. The provenance of these data is unclear, the most likely origin being ground testing (G. Hartig; priv. comm.).

Observations

The currently available calibration data is not suitable for generating encircled energy curves because it is made up of images of a crowded field where the stars contaminate each other's PSF wings. A search of the Sloan Digital Sky Survey DR13 (Albareti et al., 2016) turned up the white dwarf SDSS J132811.45+463050.8, an object better suited for this study because of its isolation.

Three external orbits were obtained to observe the target under the CAL/ACS Cycle 23 Program 14408 (PI: Avila). The target was observed using one orbit per filter (F125LP, F140LP, and F150LP), employing a 2-pt dither to eliminate bad pixels in post-processing. Each exposure was 1439s long, for a total of 2878s per filter.

The calibrated FLT images were combined using the **AstroDrizzle** task in the **DrizzlePac** software (Gonzaga et al., 2012). Steps 1 through 6 were turned off since they are not needed, essentially only masking out bad pixels and drizzling the images together. The drizzled images were produced with a plate scale of 0.03"/pix in order to keep the pixel sizes as close to native as possible.

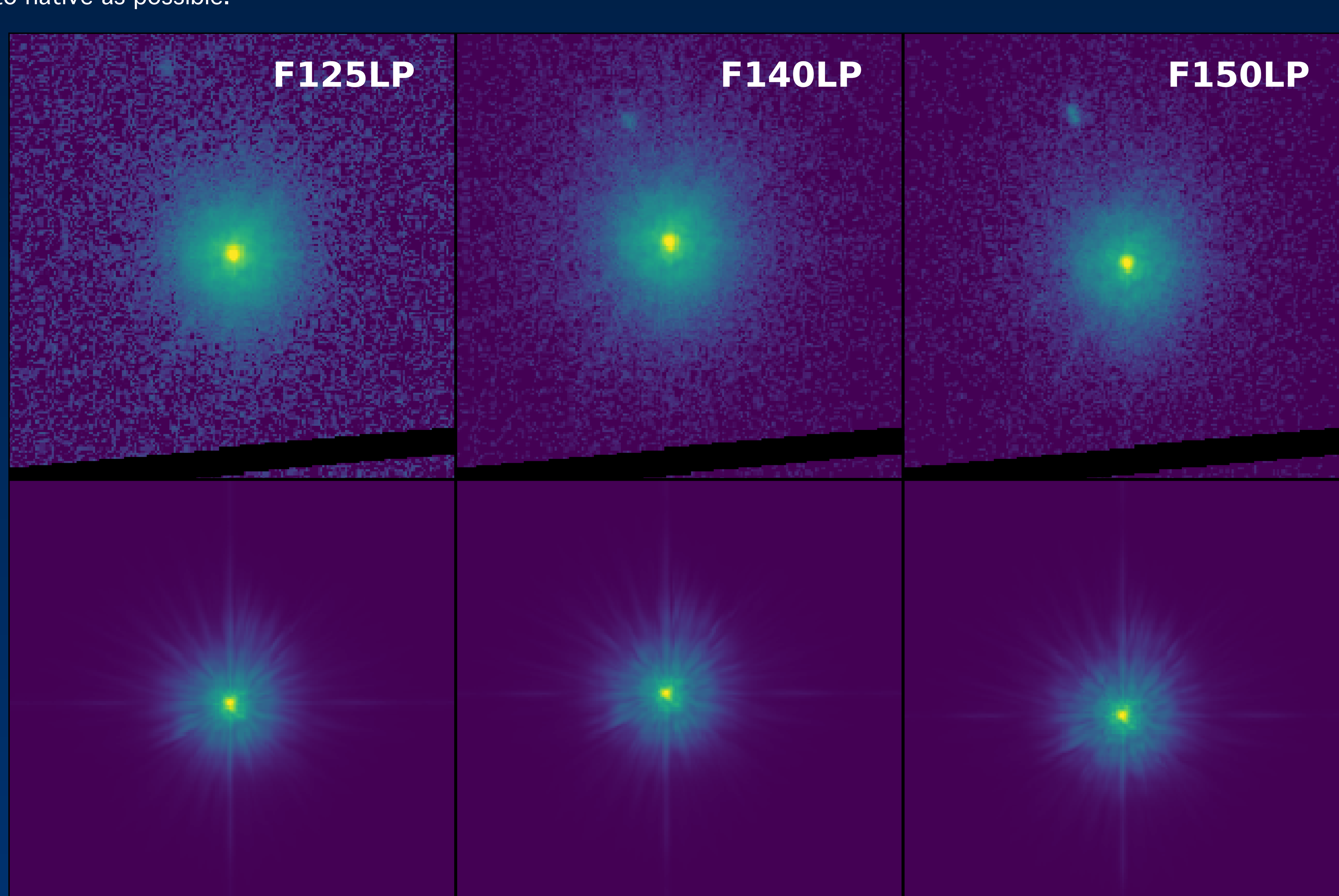

FIGURE 1: THE IMAGES OF THE OBSERVED AND MODEL PSFS. THE TOP ROW ARE THE OBSERVED, AND THE BOTTOM ARE THE MODELS. EACH BOX IS 6.0'' ON A SIDE. THE IMAGES ARE DISPLAYED WITH A LOG STRETCH WHERE THE MINIMUM IS APPROXIMATELY THE SKY, AND THE MAXIMUM IS ONE QUARTER OF THE PEAK PIXEL.

Tiny Tim Models

Model PSFs were created using the **Tiny Tim** software (Krist et al., 2011), attempting to mimic the observations as closely as possible. The model PSFs were produced using a blackbody spectrum with T_{eff} = 13390K (the same temperature as the white dwarf) and using the same location of the star as on the FLT image. The PSF images are 6.6" in diameter because that is the maximum Tiny Tim can make for this camera (Krist & Hook, 2004). Images produced by Tiny Tim include detector distortion. To produce a distortion- free PSF, the images were copied into the FLT and drizzled using the same parameters used for the observations.

Photometry

Aperture photometry was performed on the drizzled images using the **photutils** software (Bradley et al., 2016). The radial profiles were measured by taking the mean of annuli with 0.1" width. Aperture photometry, with circular apertures from 0.1 to 5.5", was performed to derive the encircled energy curves. The sky was measured by taking the mean of the images with all sources and defects masked. No sky subtraction was necessary for the Tiny Tim models since they are produced with zero background.

Figure 1 shows the images of the observed and model PSFs. The observed images show an artifact ~2" above and to the left of the star. These are optical ghosts, probably caused by internal reflections in the camera (Collins et al., 2007; ACS Instrument team, 2007). These ghosts contain approximately 1% of the total flux of the star.

The large black stripe running across the observed images corresponds to the five dead rows on the detector. A correction, equal to the sum of the masked azimuthal averages of the annuli, was applied to the total flux of the star that accounts for the missing information in these bad sections of the detector. Within a 4" circular aperture, bad pixels contain 0.13%, 0.10%, and 0.14% of the total flux in F125LP, F140LP, and F150LP respectively.

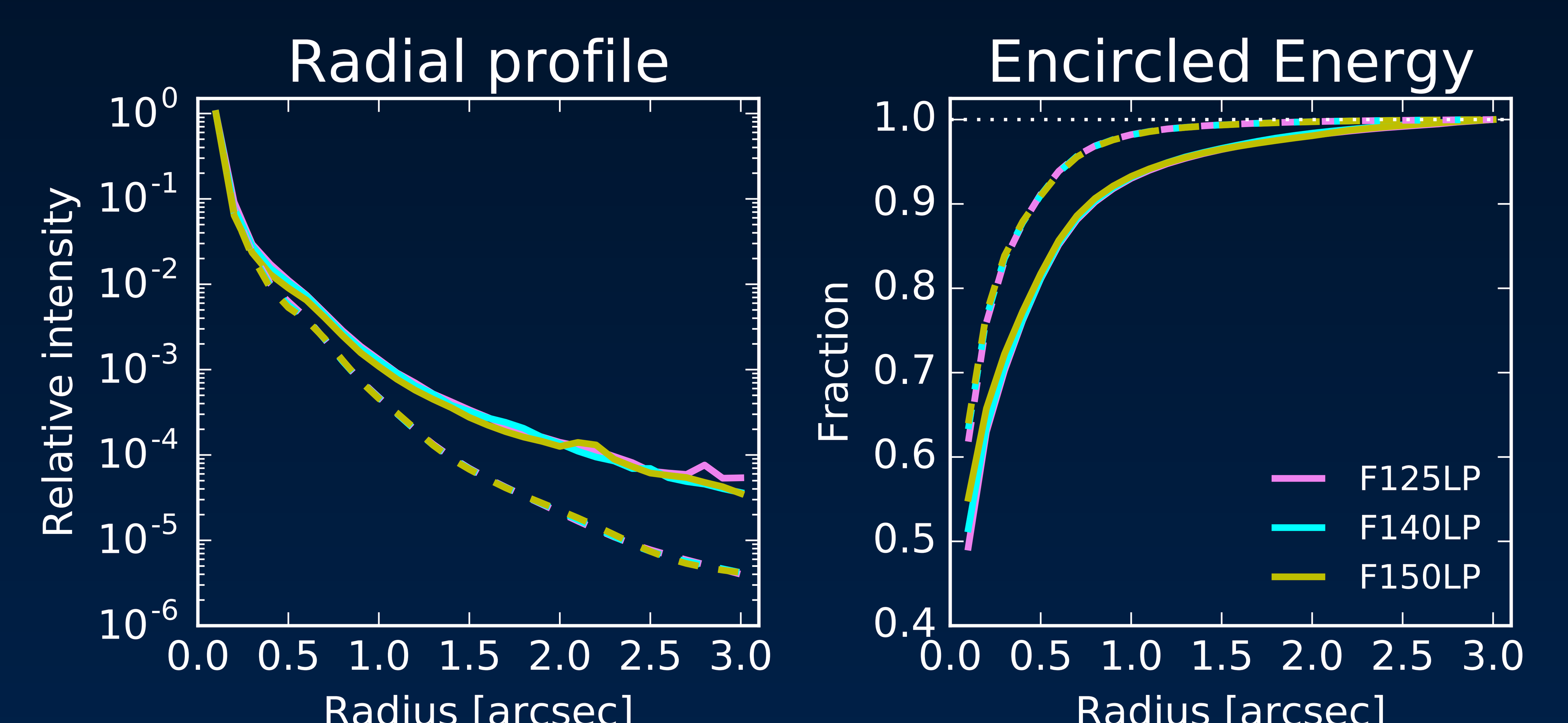

FIGURE 2: COMPARISON BETWEEN OBSERVED (SOLID LINES) AND TINY TIM (DASHED LINES) RADIAL PROFILES AND ENCIRCLED ENERGY CURVES. TINY TIM MODELS OF THE THREE FILTERS ARE SO CLOSE TO EACH OTHER THAT THEY

Results

Figure 2 shows the radial profile and encircled energy curves for the observations and the models. The radial profiles have been normalized to the value of the peak pixel. Because of the limited size of the Tiny Tim PSFs, the encircled energy curves are normalized to a 3" aperture. As can be seen on the left side of Figure 2, the observed profile has broader wings than what is predicted by the model. Note that the optical ghosts show up in these radial profiles of the observed star as bumps between 2" and 3", depending on the filter. Tiny Tim does not account for these ghosts.

A common use for Tiny Tim models is to extract encircled energy curves. The right hand side of Figure 2 shows that, when using Tiny Tim, the aperture corrections could be underestimated by ~9% at 0.5", a typical radius used for photometric measurements. This problem is exacerbated by the fact that Tiny Tim models go out to at most ~3.3" in radius, while the absolute flux calibration was derived using a 4" aperture (Sirianni et al., 2003). Considering this, it is advised that users not use Tiny Tim models to generate encircled energy curves or calculate aperture corrections for observations taken with the SBC.

Table 1 presents the aperture corrections derived from this work. The total flux is normalized using a 4" circular aperture in order to maintain consistency with the method used to calculated the zeropoints, even though the PSF wings extend out beyond that aperture. Measurements show that there is ~1% more light out to 5.5". Users should refer to this table for aperture corrections of point source photometry. Photometry can be conducted as before, but given these new corrections, SBC photometry will now be brighter.

These changes will be delivered to ReDCaT for use in **pysynphot** (Lim et al., 2015) lookup tables and delivered to the telescope's Exposure Time Calculator.

Please visit the ACS Instrument Team page at the STScI website for a full version of this report (ISR ACS 2016-05):

http://www.stsci.edu/hst/acs

	Radius [arcsec]													
Filter	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0	3.0	4.0	5.5
F125LP	0.489	0.624	0.696	0.755	0.804	0.844	0.873	0.894	0.909	0.922	0.972	0.991	1.000	1.010
F140LP	0.510	0.629	0.701	0.756	0.804	0.845	0.875	0.895	0.911	0.923	0.975	0.991	1.000	1.011
F150LP	0.546	0.651	0.715	0.765	0.809	0.848	0.877	0.898	0.912	0.923	0.971	0.990	1.000	1.013

TABLE 1: UPDATED APERTURE CORRECTIONS DERIVED FROM THIS WORK. MEASUREMENTS WERE NORMALIZED TO 4'' TO COINCIDE WITH HOW THE ZEROPOINTS WERE DERIVED (SIRIANNI ET AL., 2003).

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