

AN ASSESSMENT OF ACS/WFC RELATIVE PHOTOMETRY ON SATURATED SOURCES



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Upon full-well saturation, the pixels on the ACS/WFC CCDs will bleed excess charge onto adjacent pixels along their column. For these saturated sources, aperture photometry may report a lower flux than expected. However, this effect can be mitigated by defining an aperture which encompasses all of the pixels which contain the full-well bleed.

Here we present an assessment of relative photometry of saturated sources from observations of globular cluster 47 Tuc. We demonstrate an alternate method of aperture photometry that successfully identifies the pixels which contain the lost flux and obtains >90% accurate photometry of saturated stars out to 2 magnitudes brighter than the standard method.

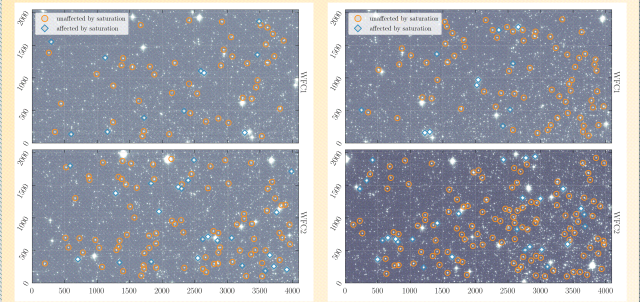
The flux of an object in the 400s exposure is expected to be 10x that of the same object in the 40s exposure. To present the functionality of the saturated source photometry, we will compare the results of 0.5" aperture photometry with aperture+ photometry.

$$\frac{F_{\{t=400s\}}}{F_{\{t=40s\}}} = 10$$

To support the hypothesis that saturation trails are a result of excess flux bleeding after pixels have reached full-well depth, we modeled the behavior of saturation trails on ACS/WFC.

To investigate the behavior of saturated sources, we analyzed two sets of F606W images centered on different parts of globular cluster 47 Tuc. These observations are an ideal test bed for photometry on saturated sources because:

- they contain a broad range of stellar magnitudes;
- the high density of the globular cluster 47 Tuc allows for evaluation of crowded field;
- the available short/long exposure times make it possible to study a variety of saturated and unsaturated sources.

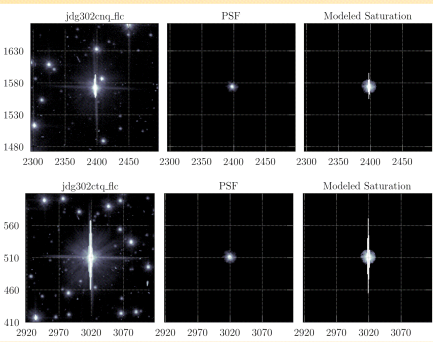
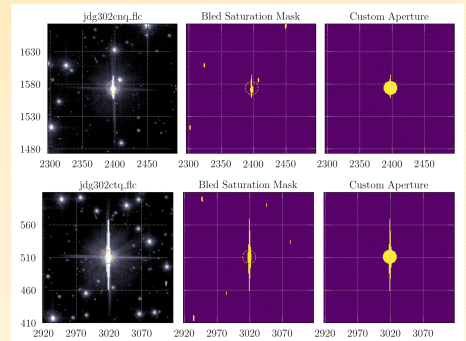


Figures 1 & 2 | The short-exposure images of 47 Tuc from the observation program 14949, with reference stars marked. For this investigation, a saturated star is defined as a star whose bleed trails extend past a 10 pixel radius from the centroid of the star in the long-exposure image.

Aperture+ Photometry

1. A mask of saturated pixels is constructed for each image from the data quality (DQ) array (Lucas et al. 2018).
2. The mask is smeared to form smooth clumps that can be associated with a single star.
3. The associated clump is combined with a 0.5" circular aperture to create a custom aperture.

Figure 3 | From left to right: the star in the short-exposure image, the smoothed saturation mask, and the custom aperture.



Saturation Trail Modeling

1. Focus-diverse PSF models are constructed for each star (Bellini et al. 2018).
2. Each PSF is normalized such that the sum of the pixels would be equal to the predicted sum for that source in the long-exposure.
3. A simple bleeding algorithm is applied, shifting charge in excess of the maximum pixel value recorded for that star in the long-exposure.

Figure 4 | Two examples of stars in the short-exposure image paired with the modeled star from the characteristic PSF and bleeding algorithm.

For each method, we calculated the maximum flux of a star for which we could recover 90% of its flux in the long-exposure image:

0.5" aperture	$18000 \pm 3000 \frac{e^-}{s}$
aperture+	$70000 \pm 6000 \frac{e^-}{s}$

The magnitude difference between these two limits is 1.94 ± 0.46 . This implies that accurate relative photometry may be obtained for stars nearly 2 magnitudes brighter using aperture+ photometry.

We performed 0.5" aperture photometry on the modeled sources to compare the observed flux recovery with the predicted recovery, as plotted as the solid green line in Figure 5.

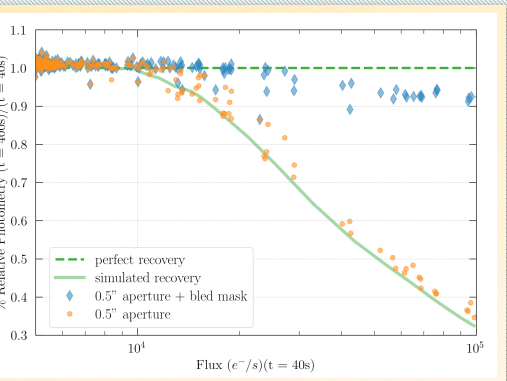


Figure 5 | The flux of a given star in a 40 second exposure plotted against percentage of expected flux recovery for the same star in a 400 second exposure.

REFS

- Bajaj, V., & Khandrika, H. 2017, Comparing Aperture Photometry Software Packages, Tech. rep., STScI
- Bellini, A., Anderson, J., & Grogin, N. A. 2018, Focus-diverse, empirical PSF models for the ACS/WFC, Tech. rep., STScI
- Lucas, R. A., Desjardins, T. D., et al. 2018, Version 9.0 (Baltimore: STScI)
- Olaes, M., Hoffmann, S., & Bellini, A. 2019, Assessing the Accuracy of Relative Photometry on Saturated Sources with ACS/WFC, Tech. rep., STScI