1997 HST Calibration Workshop
Space Telescope Science Institute, 1997
S. Casertano, et al., eds.

WFPC2 Photometry from Subtraction of TinyTim PSFs

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Abstract. Based upon the subtraction of TinyTim PSFs from PC1 point-like objects, a method has been developed to determine the optimal values for the telescope jitter and the Z4 relative focus during calibration or science observations. Using these jitter and focus values, an optimal TinyTim PSF, computed over a resampled grid, is then iteratively fitted to the object, yielding an improvement in the PSF centering, more accurate photometric results and a better detection of underlying structures. Preliminary results seem to indicate that appropriate synthetic TinyTim PSFs perform as well as observed PSFs.

1. Introduction

Subtraction of scaled PSFs from direct CCD images of quasars (or stars) not only offers the possibility of detecting the presence of host or foreground galaxies (or companions like brown dwarfs or planets) but also provides a means of deriving accurate photometry for the primary objects.

In order to address the problem of fitting the undersampled point-like object peak on the PC1, a higher resolution PSF is necessary. A high resolution PSF is also necessary in order to use some new generation deconvolution algorithms (e.g. the 2-channel PLUCY algorithm, Hook & Lucy 1994). The TinyTim application program (Krist 1996) offers us the possibility of computing synthetic PSFs with a large range of resolution. Finally, synthetic PSFs are also needed when no observed PSFs are available. In addition, a good knowledge of the Z4 relative focus and jitter (among other TinyTim parameters) during the exposure, are very important in order to derive a useful PSF.

The observations used for the tests described here were taken from the WFPC2 photometric monitoring programs. The present analysis is based on the F555W PC1 mosaic of PSFs presented by Surdej et al. (1997). Please refer to that paper for a full description of the data set.

In the MIDAS environment, Remy (1996) has developed a general, automatic procedure to derive the best photometric measurements of (multiple) point source(s). For each single observation, PSFs are derived with TinyTim for different values of the jitter and Z4 parameters. The best PSF is identified with that giving the smallest fitting residuals in terms of χ^2. The final PSF is then computed on a finer grid (10×10) with the derived optimum values for the parameters. Photometric measurements of single observations are then determined by iteratively fitting in flux and position the target with the above rebinned

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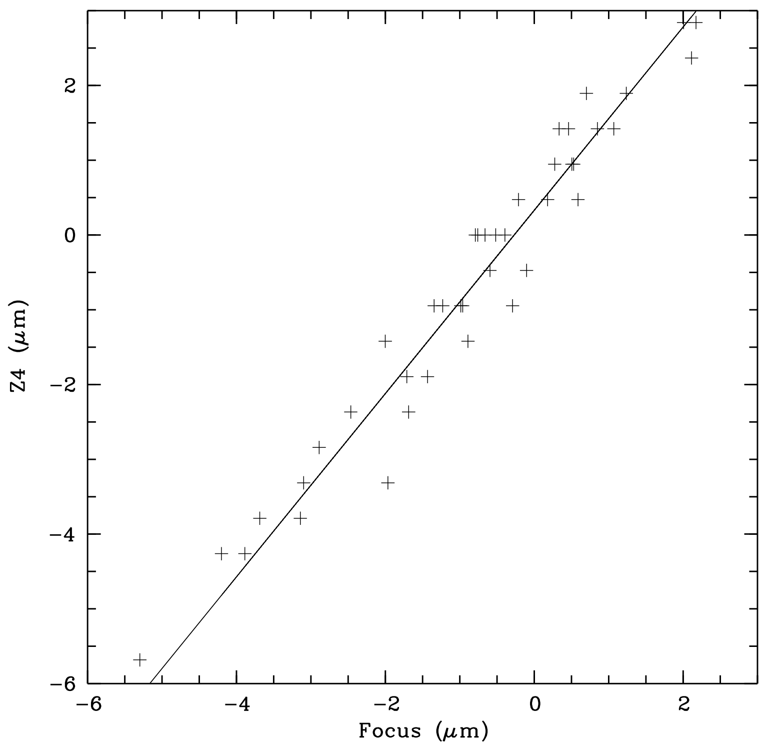

Figure 1. Z4 determined by our method versus focus measured with the phase retrieval method of Krist and Burrows (1995).

PSF (which is recentered at each iteration), using a χ^2 minimization method. A description of this automatic procedure may also be found in Østensen et al. (1997).

2. The method

2.1. Determination of the Z4 and jitter parameters

As a baseline for comparison, the Z4 and jitter parameters were determined with our technique using the 43 individual F555W images of a single object (characterized by different defocussing values).

The (Z4, jitter) domain has been sampled with a rectangular grid of 32$\times$6 points around the nominal values of these parameters; each point of the grid corresponds to a different TinyTim PSF. The sampling steps correspond to 0.42μm (Z4) and to 3 milli-arcseconds (jitter). As this method is time consuming, the PSF grid has only been computed once, taking the average position in the individual frames (X=423 Y=427), which is not far from the observed positions in most cases. Hence we avoided of constructing 32$\times$6 TinyTim PSFs for each of the 43 object positions. We then selected the optimum values corresponding to the PSF which best fits a given object.

All the optimal jitter parameters were found to be compatible with zero, as could be expected from the very short exposure times (typically $<$ 5 sseconds) used for the observations of the star GRW+70D5824.

We have plotted in Figure 1 the Z4 values in μm determined by our method versus the real focus in μm. The strong correlation indicates that our method is well suited to determine the focus to better than 1 μm, even with very approximate values used for the position of the object. The best fitting line has also been plotted.

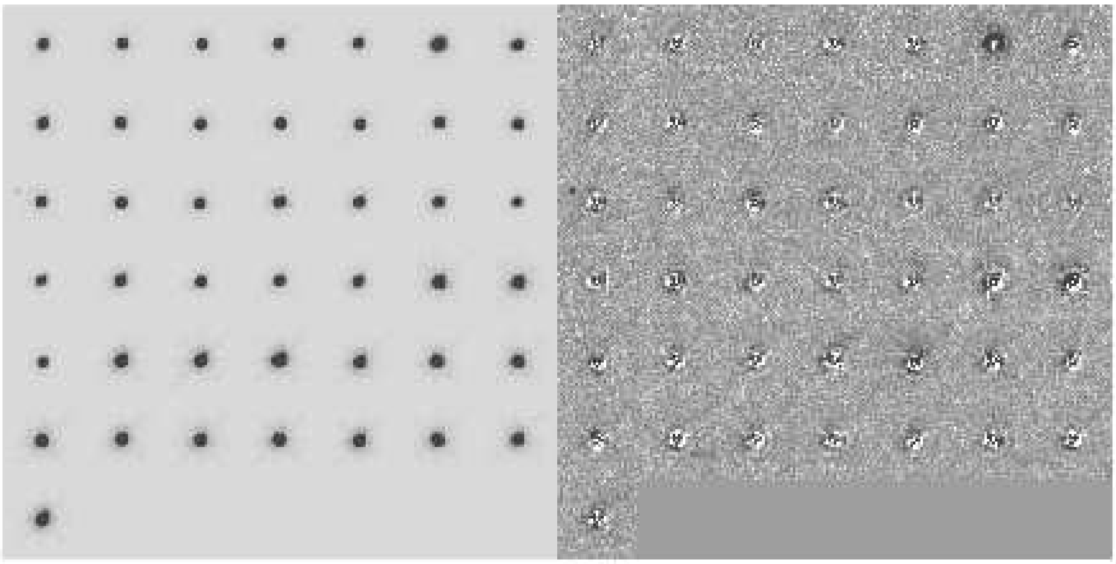

Figure 2. Mosaic image of the 43 test frames (left) and their corresponding residuals after an optimal subtraction of a resampled TinyTim PSF (right).

2.2. Iterative fitting of optimum PSFs

On the basis of the optimal values for the Z4 and jitter derived above, a PSF was constructed with TinyTim and an oversampling factor of 10. At each iteration, a fitting procedure gives a precise position for one chosen object (the 'target') on the CCD grid. The derived fractional coordinates of the target are used so that the resampled optimum PSF matches these fractional coordinates. To get a good precision and a stable resampled PSF, the process is iterated 2 or 3 times.

We present in Figure 2 the residuals of the subtraction of the optimum PSFs derived with our method. The residuals are still significant at the 5-σ limit but less significant than those derived from direct subtraction of observed PSFs as discussed by Surdej et al. (1997). The map of the residuals is significantly 'cleaner'. This should allow for better discrimination of real objects from artifacts near a point-like object.

2.3. The photometry

Finally, we show in Figure 3 the observed magnitudes of the target as a function of the focus derived with the phase retrieval method. This graph can be directly compared with Figure 2 in Surdej et al. (1997) based on the same data set.

Our results are very similar to those of Surdej et al. (1997). If we exclude the frames with large coma, the frames for which the object positions are far from nominal and the frames with CLOCK=ON, there remain 34 objects. We derive a dispersion of 0.017 for the magnitudes of this subset of 34 objects, as compared to a value of 0.014 derived from the subtraction of observed PSFs.

3. Future prospects

The tests presented here are still very preliminary, as the precise positions for the object were not input to TinyTim. We expect that by introducing these positions, the dispersion in the magnitude and the residuals of Figure 2 will be slightly reduced. TinyTim PSFs constructed with this method (including accurate input positions) have been used to analyse

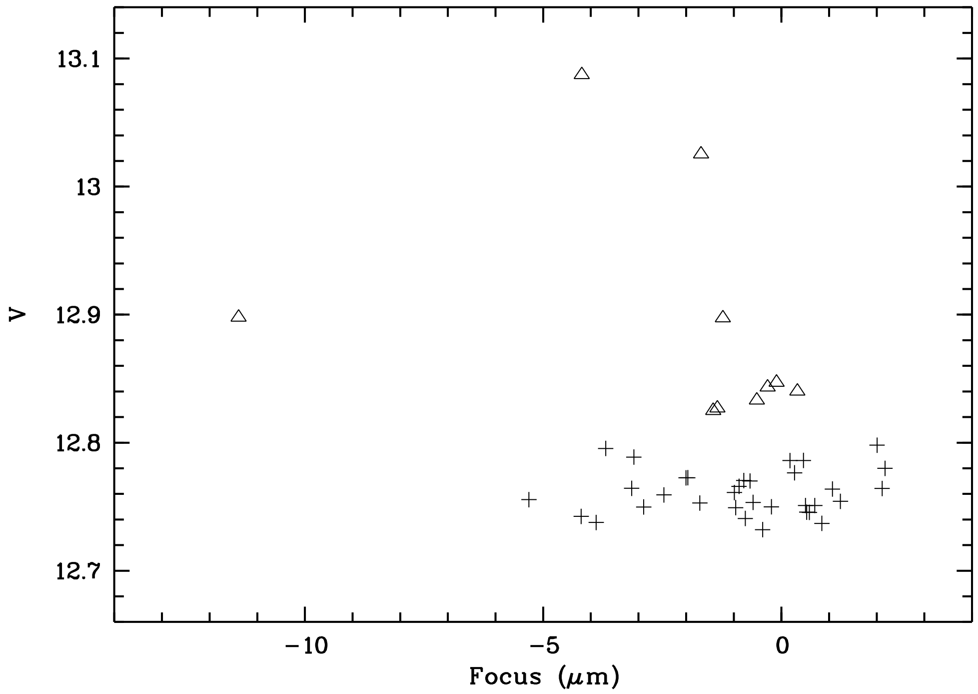

Figure 3. V magnitude of the target derived with our method versus phase retrieval focus. The triangles correspond to rejected measurements (see text).

PC1 images of the double quasars HE 1104−1805 and J03.13. A description of these studies are presented elsewhere in these proceedings (Remy et al. 1997).

Aknowledgements

This paper is based on observations made with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. This work has been supported by the SSTC/PRODEX (HST observations of gravitational lenses) project. We would like to thank Jean-François Claeskens for a careful reading of the manuscript.

References

Hook, R. A. & Lucy, L. B., 1994, in *The restoration of HST images and spectra-II*, Hanish, R. and White, R. (eds), p. 86

Krist, J., 1996, *Tiny Tim manual*, at `http://scivax.stsci.edu/~krist/tinytim.html`

Krist, J. & Burrows, C., 1995, Appl.Optics, 34, 4951

Østensen, R, Remy, M. et al., A&AS, in press

Remy, M., 1996 (Ph. D. thesis)

Remy, M., Claeskens, J.-F., & Surdej, J., 1997, this volume

Surdej, J., Baggett, S., Remy, M., & Wiggs, M., 1997, this volume