WFPC2 PSF Subtractions

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Abstract

Subtraction of scaled PSFs from direct CCD images of quasars (or stars) offers not only 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 of the primary objects.

A series of PSF subtraction tests have been performed, using observed PSFs from the WFPC2 PSF Library as well as TinyTim PSFs. Preliminary results indicate that appropriate synthetic PSFs perform as well as observed PSFs.

Specifically, using an optimally selected observed PSF, near the target on the chip (<10"), close in focus (within 1-2 μ), similar in spectral type, and with good S/N, yielded single photometric values with an RMS of about 0.01-0.02 mag. Using a carefully constructed Tiny Tim PSF, close in focus and jitter to the target image, and as close as possible to the center of the target, resulted in photometric results with an RMS similar to that achieved with the observed PSF (0.01-0.02 mag).

Observed PSFs have been drawn from WFPC2 photometric monitoring programs. Target is the spectrophotometric standard GRW+70D5824 DA3 white dwarf (V=12.77, B-V=-0.09).

Synthetic PSFs were generated via TinyTim (Krist, 1996).

Observed PSF Results

- Single star PSF (F555W, PC), photometry of 43 F555W images yields scatter typically ~0.02 mag:

  ---> single PSF leads to adequate results provided that it is close in location and focus to the target.

  ---> use of an observed PSF with relative focus position > 6 μ different results in systematic photometric error > 0.1 mag.

- Composite PSF (42 PSFs, F555W, PC), subtracted from each of the 43 original images (see Fig 1) shows no systematic dependence of derived V mag as a function of focus. Scatter of the 34 reliable observations is 0.014 mag (see Fig 2):

  ---> good photometric results with high S/N composite PSF.

- Composite PSF using subset of 34 "reliable" images yields scatter (0.014 mag) comparable to that for the 42-image composite

  ---> not much gain by removing outliers.

Tiny Tim PSF Results

- Tiny Tim model PSFs at a range of angular distances away from the target (see Fig 3):

  ---> best results obtained when using PSF within 10” of target.

  ---> mismatch in spectral type can result in nearly as much error as when using a PSF ~15-20” away from the target.

- Two steps required to derive optimum synthetic PSF:

  1) Generate grid of Tiny Tim PSFs spanning range of jitter and focus (Z4) parameters around observation values. Identify best PSF as the one giving the smallest X^2 fitting residuals.

  2) Compute final PSF by resampling best on a 10x10 grid.

- Photometry done by iteratively fitting the re-binned PSF (recen-tered at each iteration) in flux and position to the target, using an automated X^2 minimization method (Ostensen, et al. 1997; Remy et al., 1997).

Conclusions - Observed PSFs

- The best photometry is obtained when PSF is:
  - a composite (specific number of PSFs in composite not critical)
  - at focus matched to that of target's image
  - in location on chip close to target's location (<10")
  - of spectral type similar to that of target
- Resampling does not improve the photometry significantly.
- Similar tests on F814W & F439W, PC & WF3 data corroborate these F555W PC results.
- Library of WFPC2 observed PSFs available on WWW (accessible via WFPC2 top WWW page).
- Results of photometric measurements based upon subtraction of TinyTim model PSFs presented by Remy et al. (1997).

Conclusions - Tiny Tim PSFs

- Synthetic PSFs can perform as well as observed PSFs, but *construction of optimal PSF is critical.*
- To construct best PSF, use 2-step process:
  - Determine optimum jitter and focus (Z4) values. A new method for determining these optimum values has been developed and presented here.
  - Compute Tiny Tim PSFs, with best jitter/focus values, over a resampled grid, then iteratively fit to object.
- PSF subtraction results using optimum Tiny Tim PSF provide an improvement in the centering, photometric results, and detection of underlying structures. For the subset of 34 “reliable” images, the photometric RMS values (0.017) are comparable to that achieved via observed PSF subtraction (0.014 mag), see Figures 1 and 2 (see also Remy et al., 1997).

Table 1: Summary of the F555W Observed PSF subtraction photometry results. The average magnitudes and scatters were calculated from the 34 reliable observations (see text).

test case	**relative focus of composite PSF (in microns)**	**no resampling**		**2x2 resampling**	
		mag	**scatter**	**mag**	**scatter**
observed PSF, single	F>0.492	12.806	0.042	12.826	0.087
	0.492>F>=-0.820	12.809	0.022	12.750	0.065
	-0.820>F>=-2.459	12.849	0.024	12.826	0.050
	-2.459>F	12.792	0.024	12.746	0.049
observed PSF, composite of 42	2.295>F>-11.311	12.736	0.014	12.770	0.016
observed PSF, composite of 34	2.295>F>-11.311	12.769	0.014	12.767	0.021

Fig 1. V magnitudes, via PSF subtraction of 42-image **observed** composite PSF, as a function of focus value (in microns).

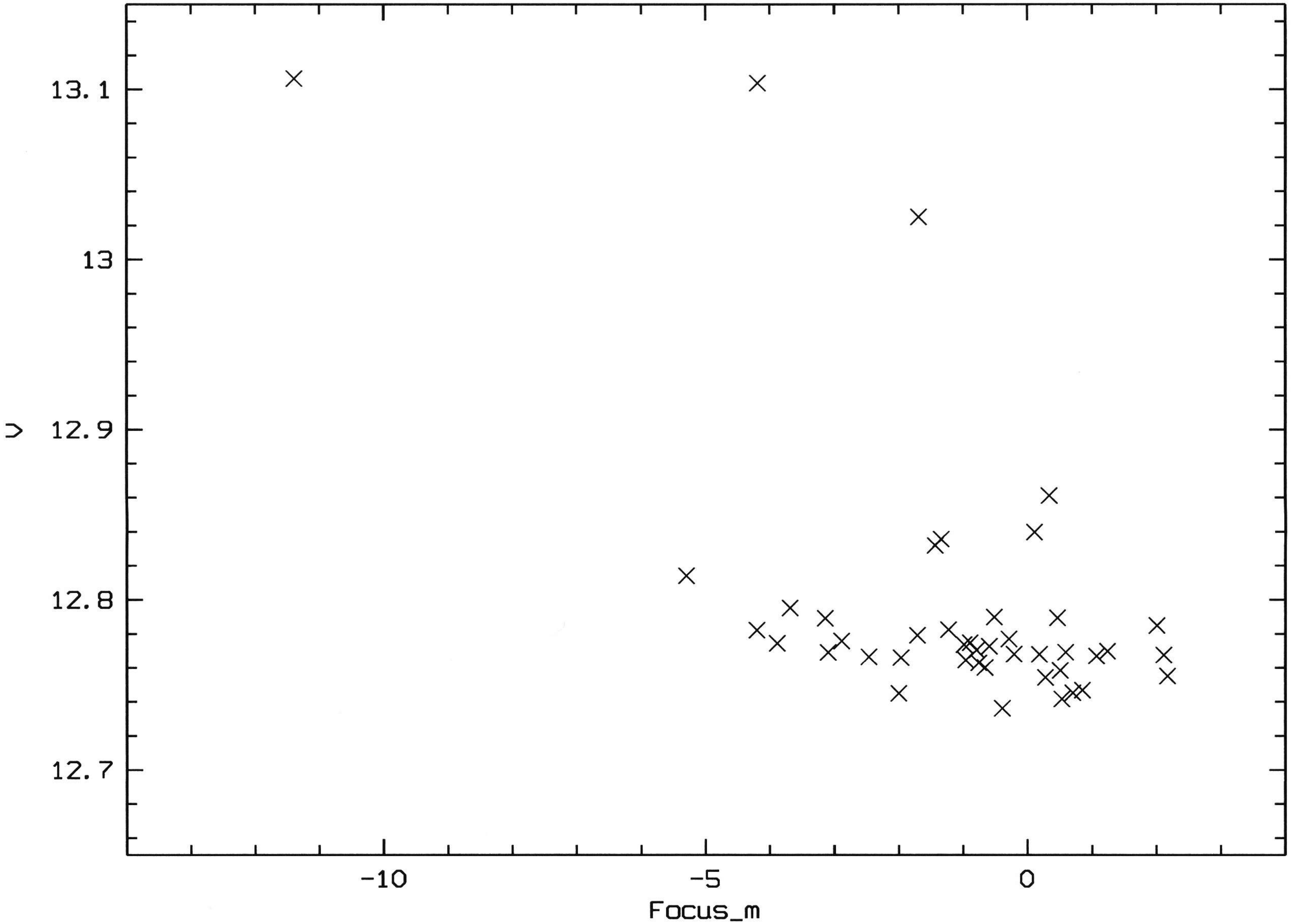

Fig 2. V magnitude of the target, as derived with synthetic PSFs, versus focus value (plus symbols represent the 34 “reliable”images).

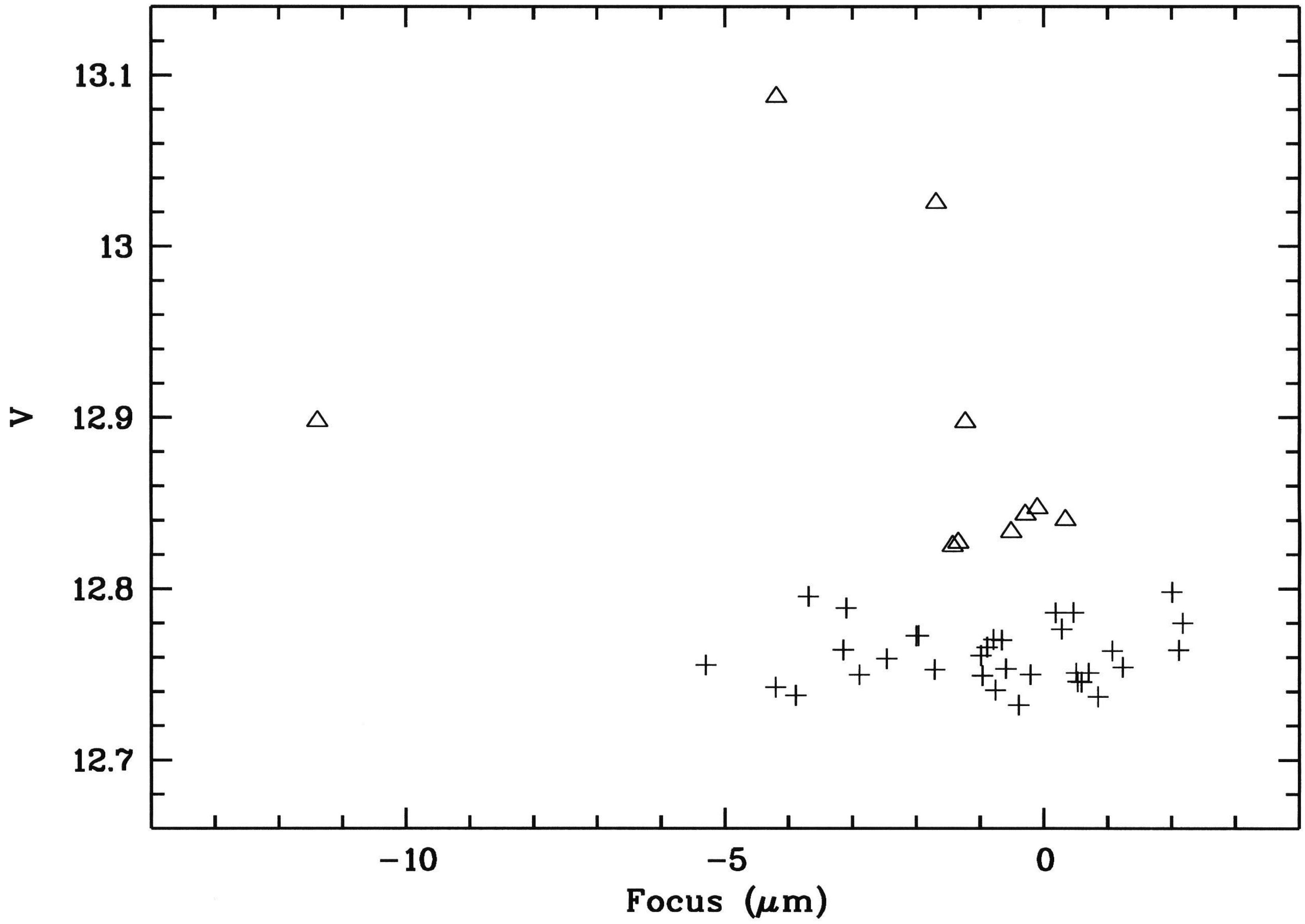

Fig 3. Changes in photometry (via observed PSF subtractions) as a function of radial distance from center (in arcsec). Additional data points at dist=0 are the results of using Tiny Tim PSFs of various spectral types (B-V=-0.297, -0.155, 0.126, 0.619, and 1.590; note: for dist>0, magnitudes were computed using B-V= -0.155).

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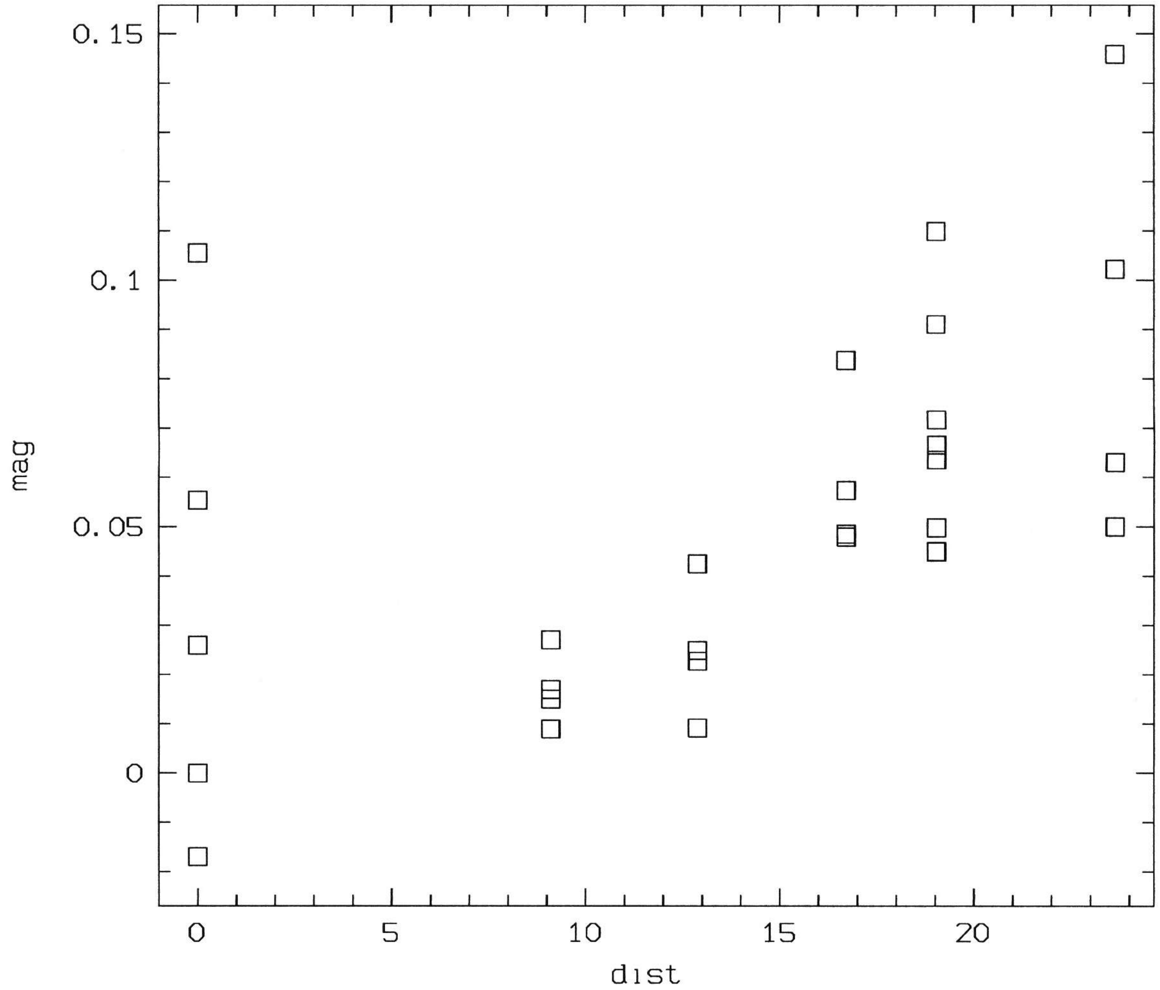

References

Krist, J., 1993, in Astronomical Data Analysis Software and Systems II, ASP Converence Series 52, R.J.Hanisch et al., editors, 530.

Krist, J., 1996, Tiny Tim Manual http://scivax.stsci.edu/~krist/tinytim.html

Krist, J., and Burrows, C., 1995, Applied Optics, 34, 4951.

Ostensen, R., Remy, M., et al., 1997, AASupp,126, 393.

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

Remy, M., Surdej, J., Baggett, S., and Wiggs, M., 1997, HST Calibration Workshop Proceedings, edited by S. Casertano et al.

Surdej, J., Baggett, S., Remy, M., and Wiggs, M., 1997, STScI Calibration Workshop Proceedings, edited by S. Casertano et al.

Wiggs, M., Baggett, S., Surdej, J., Tullos, C., 1997, STScI Calibration Workshop Proceedings, edited by S. Casertano et al.

WFPC2 Observed PSF library and links to Tiny Tim can be found via the WFPC2 top page:
http://www.stsci.edu/ftp/instrument_news/WFPC2/wfpc2_top.html
or directly at
http://www.stsci.edu/ftp/instrument_news/WFPC2/wfpc2_psf_page.html