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The Accuracy of WFPC2 Photometric Zeropoints

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ABSTRACT

The accuracy of WFPC2 photometric zeropoints is examined using two methods. The first approach compares the zeropoints from five sources: Holtzman (1995), the HST Data Handbook (1995 and 2002 versions), and Dolphin (both 2000 and 2002 versions). We find the rms scatter between the different studies to be: 0.043 mag for F336W, 0.034 mag for F439W, 0.016 mag for F555W, and 0.018 mag for F814W. The second approach is a comparison of WFPC2 observations of NGC2419 with ground-based photometry from Stetson (from his website) and Saha et al. (private communication). The agreement between these comparisons is similar to the historical zeropoint comparisons. Hence we conclude that the true uncertainty of WFPC2 zeropoints is currently about 0.02-0.04 magnitudes, with some dependence on filter. The largest errors seen are 0.07 magnitudes. Since Poisson statistics would predict that 1% absolute accuracy should be attainable, we conclude that there are still systematic error sources which have not yet been identified.

1. Introduction

The ultimate goal of this project is to determine if 1% absolute photometry is possible using WFPC2. In principle this should be attainable, as evidenced by the fact that the short-term rms in our photometric monitoring observations for the primary broadband filters are < 1%. The challenge is to: 1) understand the various systematic errors well enough (e.g., CTE loss, variable focus, geometric distortion, etc.) and 2) match the zeropoints to existing standards with enough precision to make this possible. In this report we address the second issue by examining the accuracy of WFPC2 photometric zeropoints using two methods.

The first approach compares the zeropoints from five sources:
•Holtzman (1995)
•HST Data Handbook (1995)
•HST Data Handbook (2002)
•Dolphin (2000)
•Dolphin (2002)

These five studies use largely independent methods to determine zeropoints (e.g., the Data Handbook uses a single photometric monitoring star and the SYNPHOT software while Dolphin uses ground-based photometry of Omega Cen and NGC 2419). Hence the resulting scatter provides an empirical estimate of the true uncertainty.

The second approach is a comparison of WFPC2 observations of NGC2419 with ground-based photometry from Stetson (from his website) and Saha et al. (private communication). The resulting scatter between these determinations, along with the historical scatter outlined above, provides our best estimate of the true uncertainty in the WFPC2 zeropoints.

The Target NGC2419

Figure 1 shows a representative image (out of about 30 datasets analyzed) from NGC2419 (F814W, u4ct0106r, WF3, exptime = 40s, date-obs = 1997-11-18).

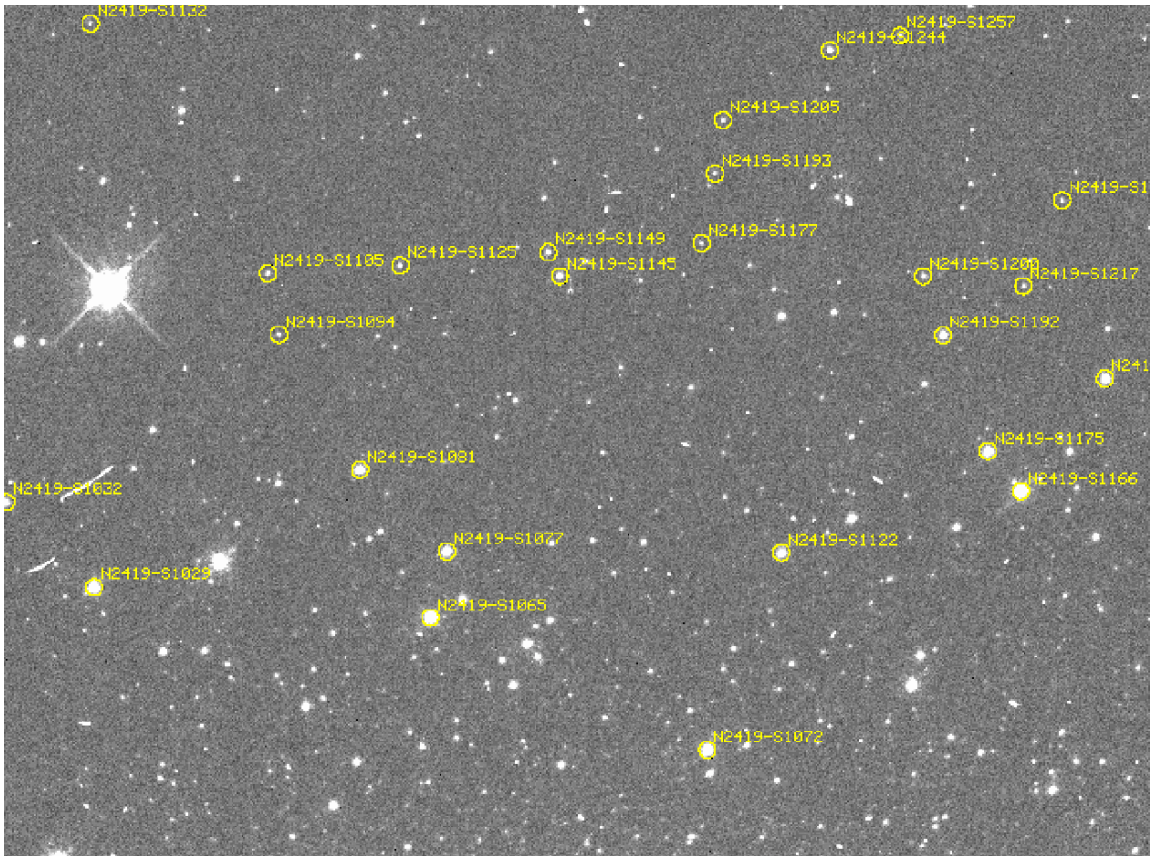

Figure 1: NGC2419 with labelled target stars.

2. Method #1: Historical Comparisons

Figure 2 shows the difference between the HST Data Handbook (DHB, 2002) zeropoints and the Stetson magnitudes in F555W for a sample field.

Figure 3 shows a comparison between five different historical zeropoint determinations. The sources are Holtzman (1995, empty circle), HST Data Handbook (1995, filled circle), HST Data Handbook (2002, empty square), Dolphin (2000, crosses), and Dolphin (2002, filled squares).

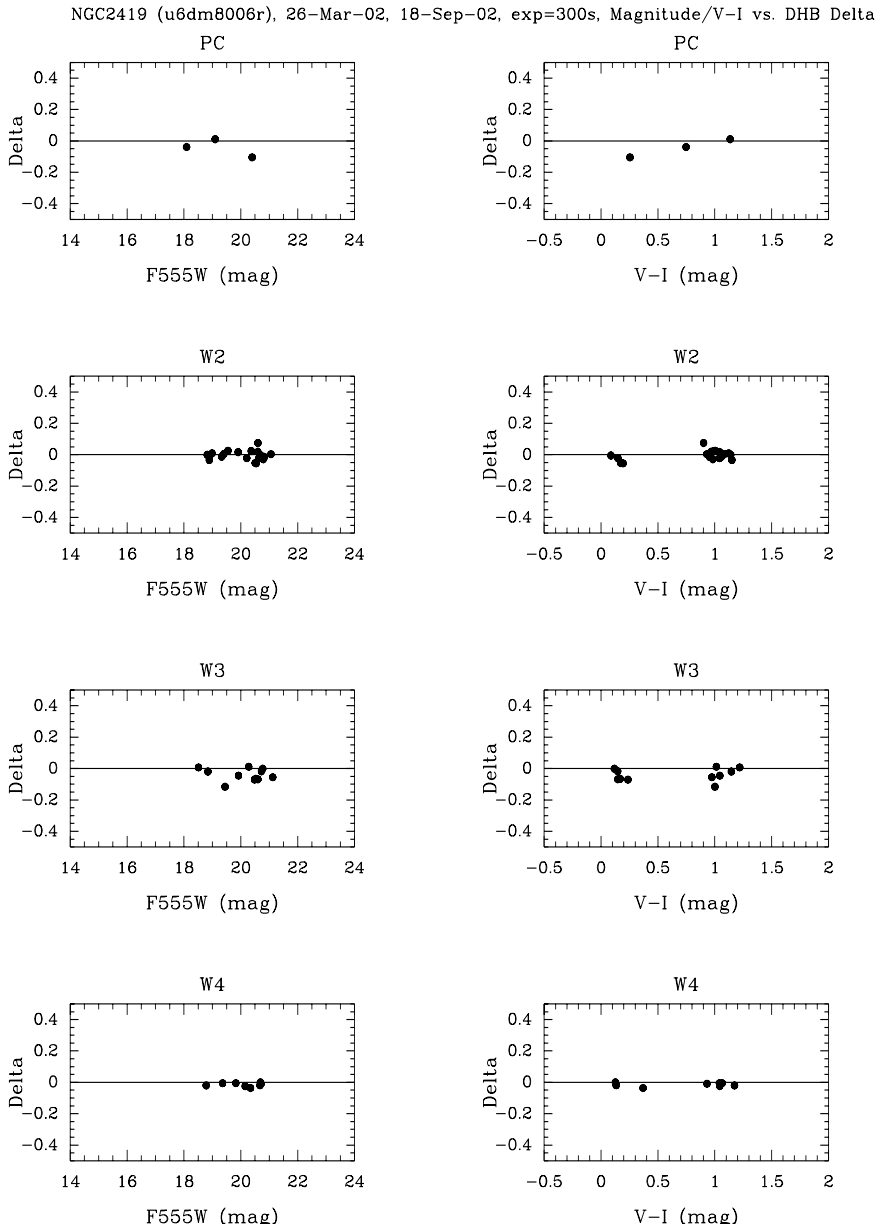

Figure 2: Example plot for F555W (dataset = u6dm8006r, exptime = 300s, observation date=2002-03-26). The delta is the magitude when using zeropoints from the HST Data Handbook (DHB, 2002) minus the Stetson magnitude.

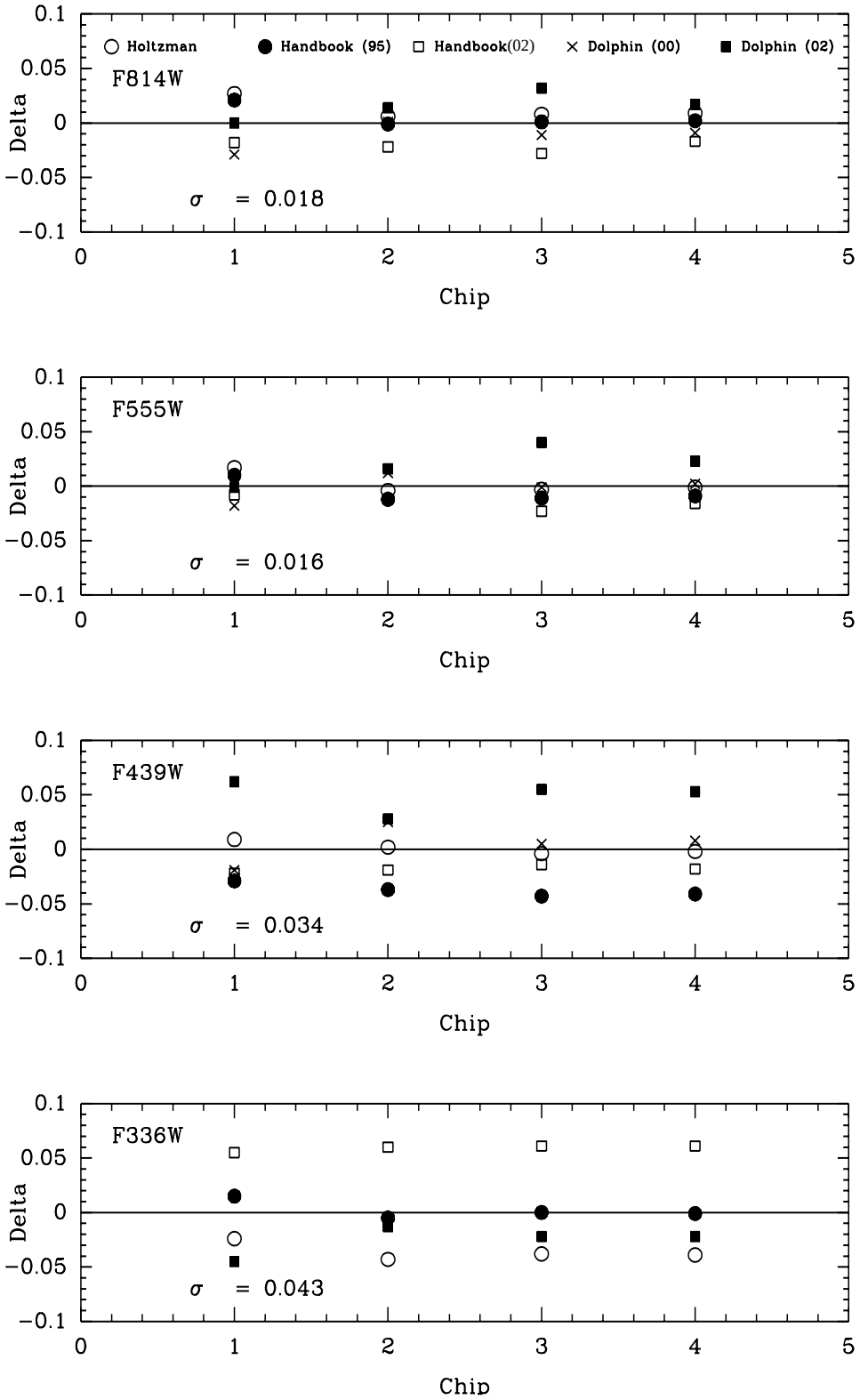

Figure 3: Historical zeropoint comparison between five different sources. The delta along the vertical axis is the residual with respect to the mean of the zeropoints in magnitudes.

3. Method #2: Comparison to ground-based data by Stetson and by Saha

We analyzed WFPC2 data of NGC 2419. The data were calibrated using the WFPC2 pipeline and combined with cosmic-ray rejection.

The images were multiplied by a geometric distortion correction image, since we are doing point-source, rather than surface photometry. Aperture photometry was performed on each dataset using a 0.5” radius, and the values were corrected to infinity by subtracting 0.1 magnitudes (Holtzman 1995). Very bright stars and very faint stars were trimmed from the sample, due to suspected saturation and excessive noise, respectively. Searches were then performed to identify stars that matched identical stars from Stetson’s (www site) data files. The Dolphin (2002) CTE correction and the Holtzman color transformations were applied. The sample was further trimmed by applying graduated isolation criteria with a limit approximating a 4-magnitude difference at 5" distance. Finally, plots were produced for each dataset showing the residual versus magnitude and V-I photometric color.

We present the results of our examination for the target NGC2419 in the filters F555W and F814W. The table shows the average and dispersion of the photometric residuals for each filter and chip. The data are plotted as a function of exposure time and date in Figures 4 and 5.

Table 1: NGC 2419 Photometric Residual Statistics for F555W and F814W.

Filter	Chip	# in Stetson Sample	Stetson Residual Mean	Stetson Residual Dispersion	# in Saha Sample	Saha Residual Mean	Saha Residual Dispersion
F555W	PC1	22	-0.0087	0.0303	10	-0.0229	0.0412
	WF2	29	0.0106	0.0412	13	0.0010	0.0293
	WF3	32	-0.0083	0.0403	13	-0.0025	0.0321
	WF4	16	-0.0048	0.0270	12	-0.0264	0.0531
F814W	PC1	46	-0.0197	0.0346	8	-0.0708	0.0394
	WF2	64	-0.0255	0.0374	16	-0.0573	0.0304
	WF3	68	-0.0310	0.0306	14	-0.0654	0.0269
	WF4	48	-0.0143	0.0313	11	-0.0746	0.0414

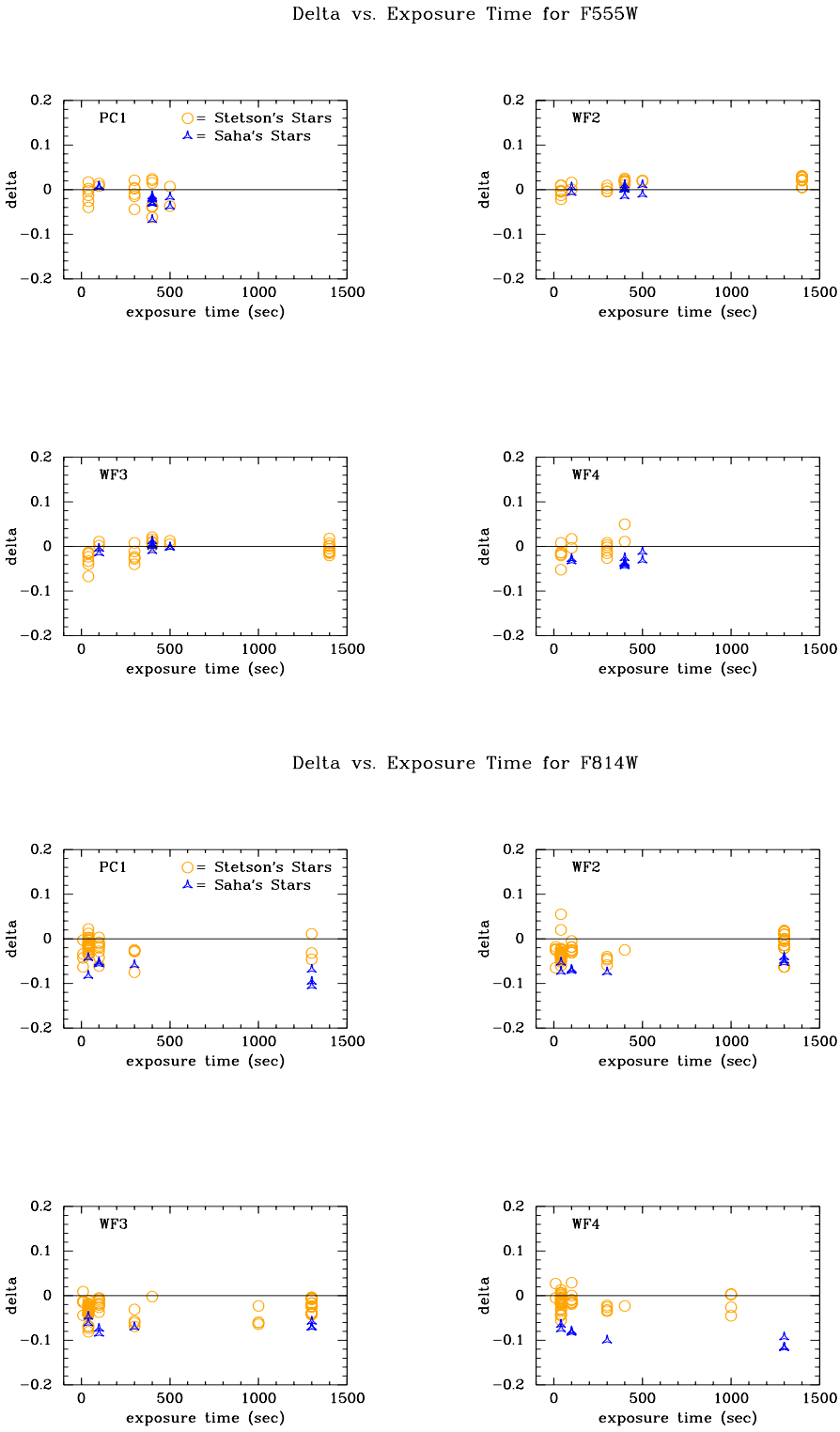

Figure 4: The figures above show the photometric residual as a function of exposure time for F555W (top) and F814W (bottom). The grey circles show the results from the comparison with Stetson's stars, the black crosses show the results from the comparison with Saha's stars.

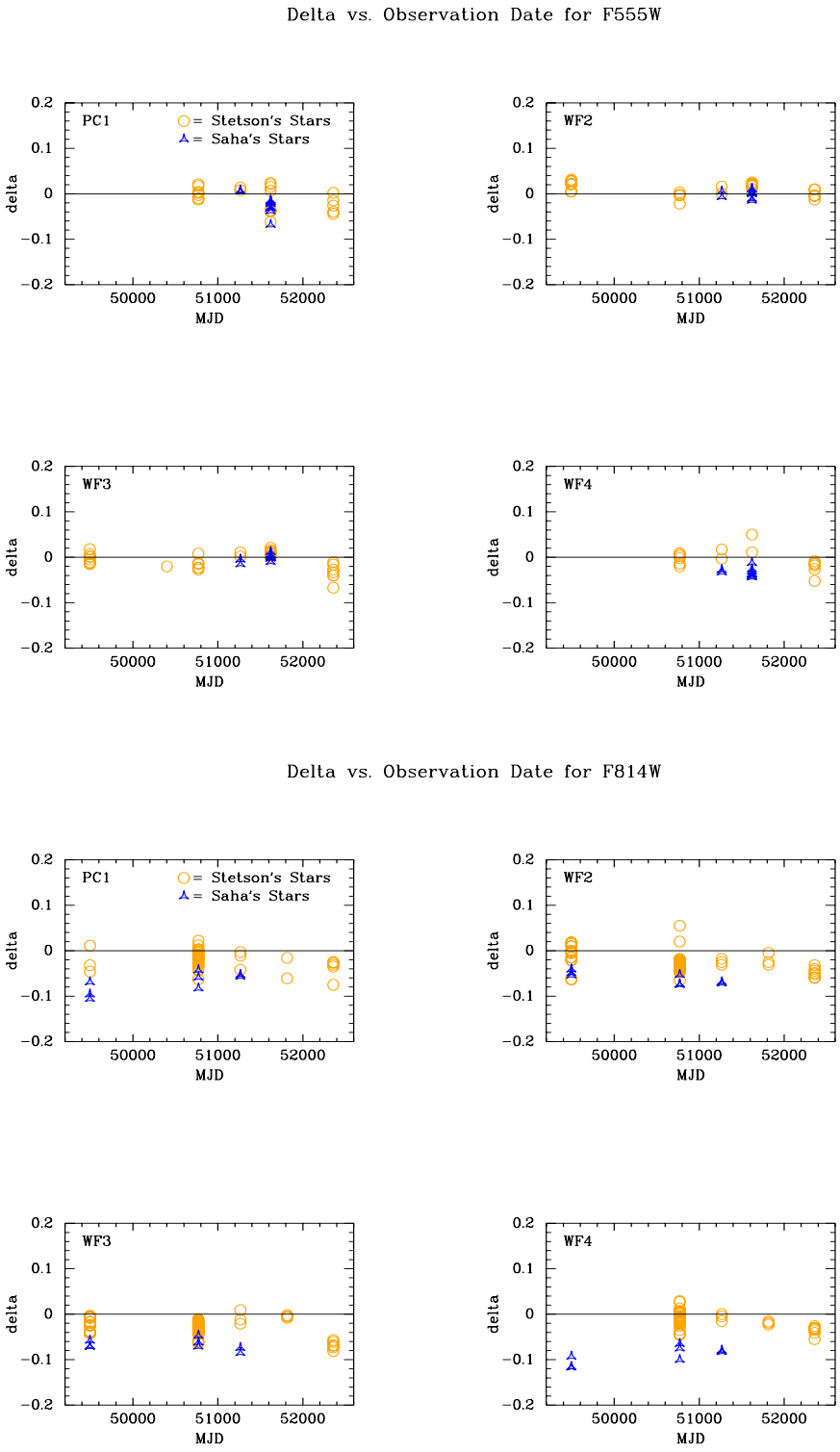

Figure 5: The figures above show the photometric residual as a function of observation date (in MJD) for F555W (top) and F814W (bottom). The grey circles show the results from the comparison with Stetson's stars, the black crosses show the results from the comparison with Saha's stars.

The formal error of the mean for the values in Table 1 is (residual dispersion/$\sqrt{N}$), a value that is usually near or under 1%. We notice that the results for F814W in the Saha Sample show a larger residual mean. It also needs to be pointed out that the Stetson and Saha data are not in mutual agreement either. This appears to be due to slightly different filter transmission curves and associated color terms for filters used by Stetson and by Saha. This was found independently in a study by Sirianni and Saha (private communication).

4. Conclusions

1.The true uncertainty in the current WFPC2 zeropoints, as judged by either the historical zeropoints or comparisons of HST observations of NGC2419 with ground-based photometry, is about 0.02 magnitude for F555W and F814W, and about 0.03-0.04 for F439W and F336W. For the Saha sample in F814W we see an uncertainty of 0.07, which is probably due to different color terms in the ground-based filters used by Stetson and by Saha.

2.The statistical uncertainty would predict that an accuracy of 1% should be attainable. The fact that the true uncertainty is larger indicates that there are as yet unidentified error sources.

3.There do not appear to be any obvious trends in the zeropoint deltas versus exposure time and time of observation. The disagreement between different studies is still evident even when data are taken at similar epochs or with the same exposure times.

References

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