SPACE TELESCOPE SCIENCE INSTITUTE
Operated for NASA by AURA

Technical Instrument Report WFPC2-02-01

SMOV3b Check of the WFPC2 Point-Spread-Function

V. Kozhurina-Platais, L.M. Lubin, and A.M. Koekemoer
May 9, 2002

ABSTRACT

We examine the Point-Spread-Function (PSF) of the WFPC2 after the Servicing Mission 3b using dithered observations of the rich globular cluster, Omega Cen. Comparisons to previous measurements of the PSF which were made after the last two servicing missions (SM2 and SM3a) indicate that no significant variations in the PSF have occurred. We also present an analysis of the shape of the PSF as a function of five positions on the Planetary Camera (PC) chip.

Observations and Data Reduction

Following the procedures used after the previous two servicing missions (SM2 and SM3a) (see Biretta et al. 1997; Casertano et al. 2000), images of the globular cluster Omega Cen were obtained to characterize the Point-Spread-Function (PSF) of the WFPC2 after the Servicing Mission 3b (Proposal 8954). Four dithered images of Omega Cen, each with a duration of 100 seconds, were obtained in the broad-band F555W and F814W filters on March 25, 2002. The dithered images were sub-stepped by one-third of a pixel in each coordinate to provide a critically sampled PSF. We note that the focus had stabilized by the time these observations were taken.

In order to make a comparison to previous measurements of the PSF made with Omega Cen, we analyze and present the results in the F555W filter. The images were combined using the **dither** routine in IRAF, and in particular the IRAF scripts of A. Fruchter (private communication) , according to the procedures described in the HST Dither Handbook

(Koekemoer et al. 2002). To produce our final drizzled images, we have used a scale that is one-half of the original pixel size and a pixel footprint of 0.7.

In order to compare our measure of the PSF with previous measurements made after the last two Servicing Missions, we have performed a similar analysis to that presented in Biretta et al. (1997) and Casertano et al. (2000). In these studies, a composite PSF was made using a number of bright stars which were not saturated, were well isolated, and were located near the center of the PC chip. The PC was used because its pixel scale is more than a factor of two smaller than in the Wide Field (WF) cameras. As a result, the observed PC PSF is a better indicator of the telescope and instrumental optics than the observed WF PSF which is dominated by the pixel response function.

For our study, we use the task **psf** in the IRAF package **noao.digiphot.daophot**. This task implements the empirical PSF fitting as a sum of an analytical function and look-up table(s) of residuals between the actual PSF and the fitting function (Stetson 1987; Stetson, Davis & Crabtree 1990). This lookup table is used as additive corrections from the integrated analytic function to the actual observed empirical PSF. Five additional lookup tables containing the first derivatives of the PSF in x and y and the second order derivatives of the image with respect to x^2, $x*y$, and y^2 are also written. This model permits the PSF fitting process to take into account smooth linear or quadratic changes in the PSF across the frame. It is well known that a Lorentzian function provides the best representation of the PSF in WFPC2 data because it has an undersampled core and extended wings. However, we have instead used a Gaussian analytic function with the six lookup tables described above. To construct a composite PSF, we select about 30 bright, unsaturated, and isolated stars at the center and the four corners of the PC chip and use the task **psf** to create a two-dimensional, composite PSF from the stars in each of the five regions. This technique allows us to make a comparison between previous measurements of the PC PSF made in the center of the chip, as well as to characterize its variation across the chip.

Results

We use the task **radprof** in the IRAF package **noao.digiphot.apphot** to measure the radial profile of the composite stellar image made from the stars in the central region of the PC chip. The resulting radial profile is shown in Figure 1. The counts have been normalized to 1 at the profile center and have been plotted as a function of the pixel distance from the profile center. The best-fit Gaussian, with a full-width-half-maximum (FWHM) of 0.066”, is shown for comparison. The error on the FWHM is approximately +/- 0.002”. The shape of the PSF is unchanged with respect to the previous measurements. In Biretta et al. (1997) and Casertano et al. (2000), the PC PSF is well described by a Gaussian curve within the half-maximum point. They find that the FWHM of the best-fit Gaussian is 0.064”, consistent with our measurement. In addition, we find an excess of up to 10% of the peak counts with respect to the best-fit Gaussian outside that radius. That is, at distances greater than about 1 PC pixel from the profile center, we see that the stellar counts have intensities relative to peak which are approximately 10% greater than the best-fit Gaussian curve. This behavior was also observed in the measurements made in 1997 and 2000.

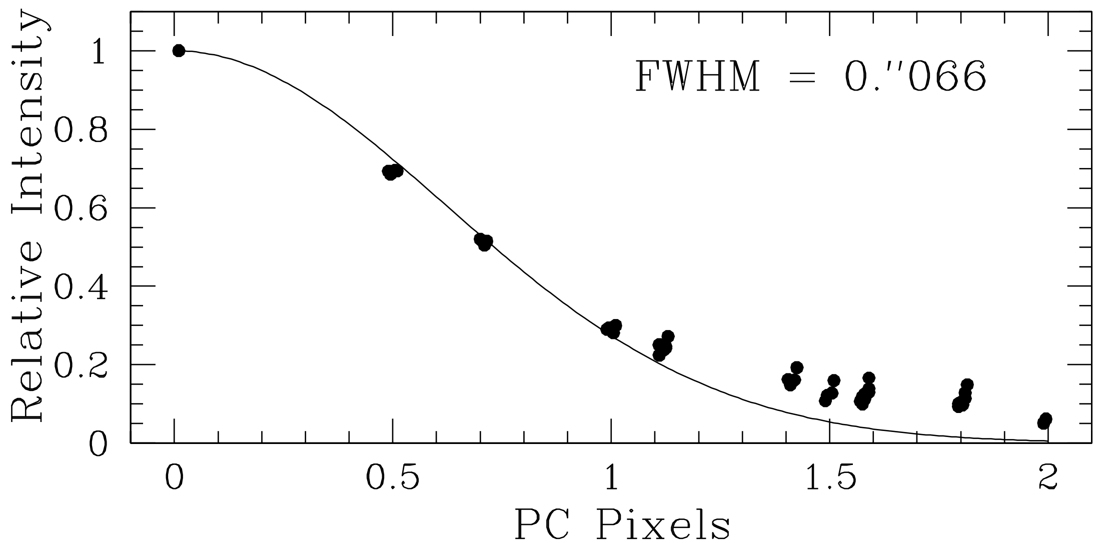

Figure 1: Radial profile of the PSF in the central region of the WFPC2 PC image of Omega Cen taken after SM3b. A composite stellar image was created using about 30 isolated, unsaturated stars near the center of chip with the IRAF task **psf.** The radial profile was measured using the IRAF task **radprof**. The best-fit Gaussian model with FWHM = 0.066” is shown by the solid line.

We have also examined how the PSF varies with chip position. To examine this behavior, we have calculated the radial profile of the composite stellar images by making cuts along both the x and y direction. In Figure 2, we show the x and y radial profiles as a function of five chip positions. In the five panels, we plot the PSF, from top to bottom, for the center, lower left, lower right, upper right, and upper left, respectively. The observed PSF is shown as the dotted line, while the solid line represents the analytic Gaussian function. The width of the Gaussian model (in PC pixel units) is listed in each panel. To enhance the visibility of the fine details in the observed PSFs, we show in Figure 3 the difference between the observed profile and the fitted model. We can easily see from the residuals that there is a difference of about 10% in the profile wings and about 20% in the profile core which is due to the poor representation of the observed PSF by the analytic Gaussian function.

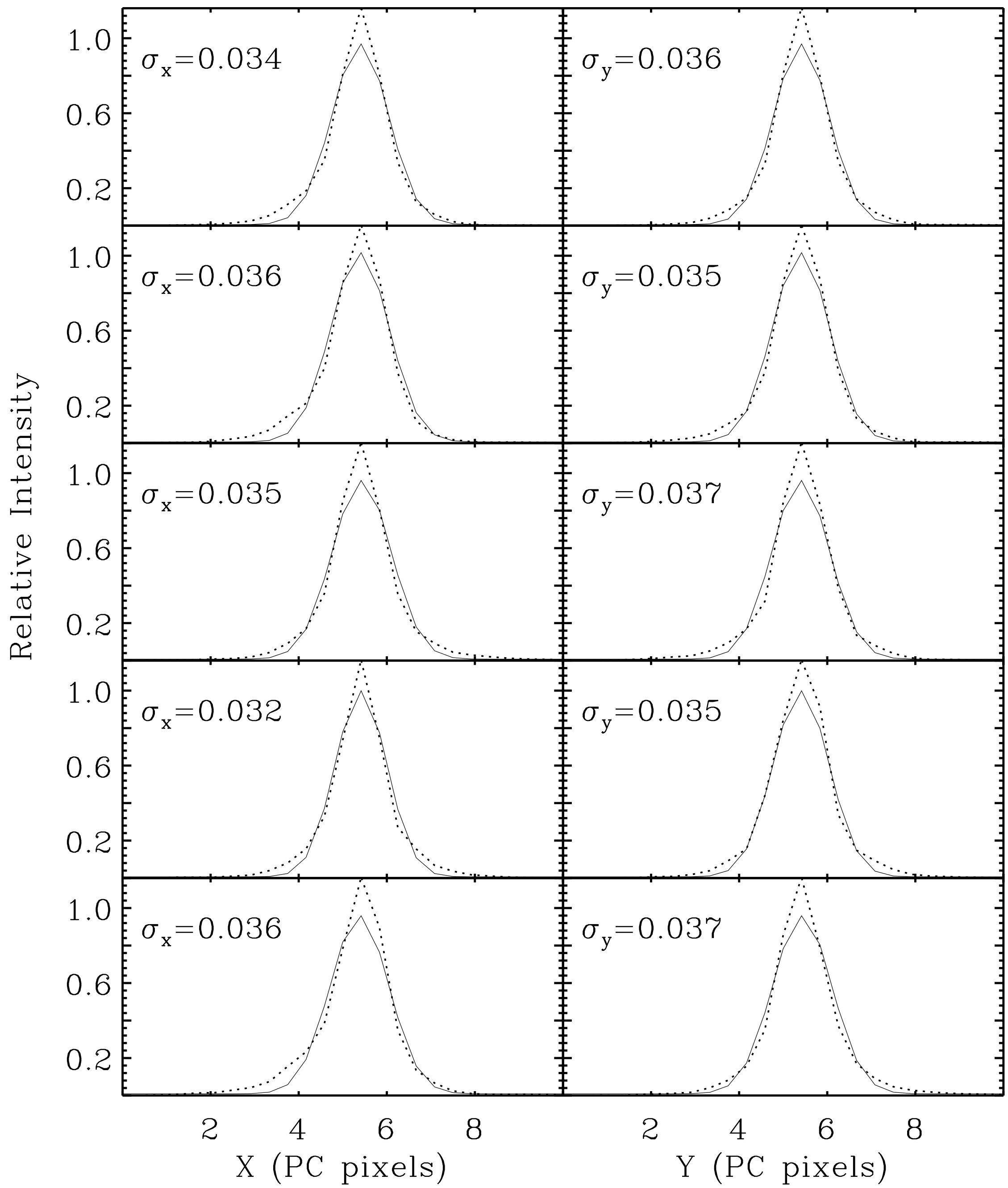

Figure 2: Composite stellar profile as a function of position on the PC chip. Radial profiles were made by making cuts along the x (left) and y (right) axis. The dotted and solid lines indicate the observed profile and the fitted Gaussian model, respectively. The width of the Gaussian model (in PC pixels) is listed in each panel. The panels, from top to bottom, represent the observed PSF in the center, lower left, lower right, upper right, and upper left of the chip, respectively.

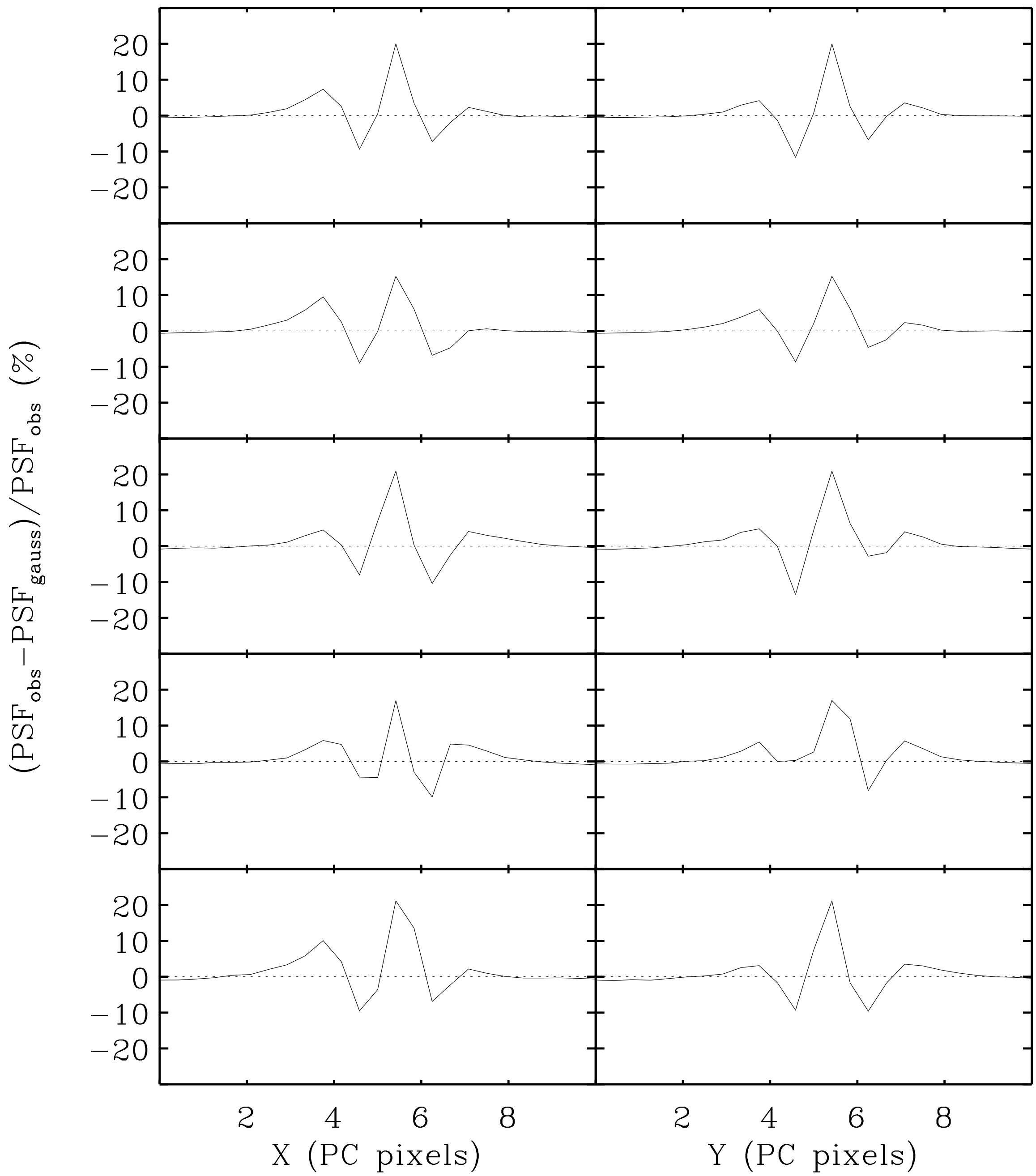

Figure 3: Residuals (in percent) between the observed PSF (dotted lines in Figure 2) and the best-fit Gaussian model (solid lines in Figure 2) as a function of chip position. The panels are the same as shown in Figure 2.

In Figure 4, we show the contour plots of the composite stellar image as a function of chip position. As previously noted (Krist & Burrows 1995), the observed PSF varies as a function of the position on the PC chip, with the off-center PSFs being noticeably more asymmetric due to coma and astigmatic aberrations. This behavior is consistent with the level of residuals observed in Figure 3.

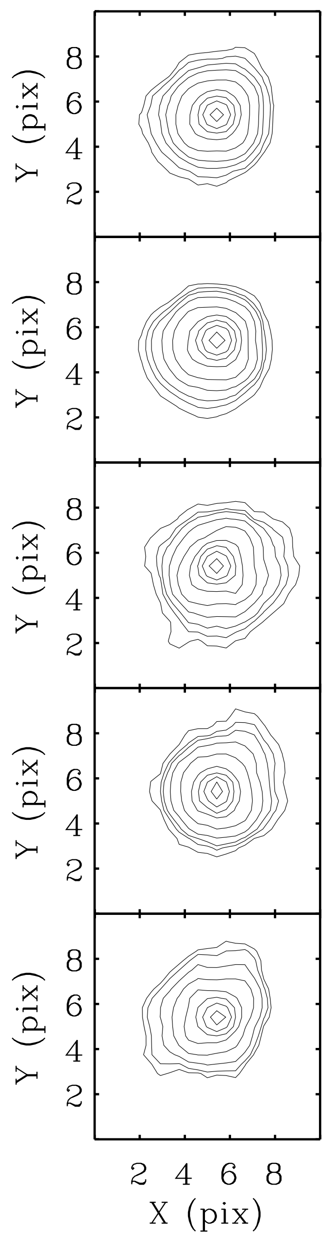

Figure 4: Contour plots of the composite PSF as a function of position on the PC chip. The panels, from top to bottom, represent the observed PSF in the center, lower left, lower right, upper right, and upper left of the chip, respectively.

Conclusions

We have measured the PSF on the PC chip of WFPC2 after the Servicing Mission SM3b. Comparisons made with previous measurements of the width and shape of the PSF indicate that no substantial changes in the PSF have occurred. The PSF can be defined by a Gaussian curve within the half-maximum point. The FWHM is approximately 0.066”, fully consistent with measurements made after the previous two Servicing Missions. We also characterize the change in the PSF as a function of chip position by measuring the PSF at the center and the four corners of the PC chip. As previously noted, there are clear differences in the shape of the PSF, with the off-center PSF being noticeably more asymmetric.

References

Biretta, J. et al. 1997, “Results of the WFPC2 Post-Servicing Mission-2 Calibration Program,” Instrument Science Report WFPC2-97-09.

Casertano, S. et al. 2000, “Results of the WFPC2 Observatory Verification after Servicing Mission 3a,” Instrument Science Report WFPC2-00-02.

Koekemoer, A.M. et al. 2002, “HST Dither Handbook,” Version 2.0 (Baltimore: STScI).

Stetson, P.B. 1987, PASP, 99, 191.

Stetson, P.B., Davis, L.E., & Crabtree, D.R. 1990, in ASP Conf. Ser. 8, “CCDs in Astronomy,” ed. G.H. Jacoby, 289

Krist, J., & Burrows, C. 1995, Applied Optics 34, 4952.