FLAMINGOS Performance – III

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1. Introduction

This report summarizes a continuing effort to understand the performance of FLAMINGOS for both imaging and spectroscopic applications. This report focuses on the photometric uniformity over the array.

2. Background

The issue of the "lost flux" was addressed in a 28 July 2005 memo by Steve Eikenberry, Andrea Stolte, and Nick Raines. They carefully investigated the PSFs of stars at various locations in the FLAMINGOS field, concentrating on a location in the upper right quadrant where comparison with 2MASS photometry had indicated significantly fainter fluxes. Other observers had commented on this as well. They determined that stars in that region did not vary significantly from others in the field by "quick look" diagnostics such as Gaussian fitting using IRAF, with perhaps a 10% increase in FWHM. However, PSF fitting showed that stars in this region had very broad wings at radii greater than 4 pixels, resulting in an extended halo which would be typically missed with standard aperture photometric extraction. As noted in the introduction, this was speculatively attributed to scattering by the clearly deteriorating AR coating on the BaF_2 camera field lens. The AR coating was removed by Janos in November 2005 was to solve this problem, but feedback on the post-rework image quality has been limited.

As noted in the first of these reports (17 August 2006), a quick analysis of an image of the M56 field taken by Ken Rines showed that the PSFs of several stars distributed over the field, including within the upper right quadrant, were almost identical, strongly suggesting that the rework of the BaF_2 lens had fixed the problem. Nonetheless, additional, more quantitative tests were needed.

3. Observations

The relatively clear (although non-photometric) night of 28 September 2006 was used for a first-cut test at the photometric uniformity. The core of the dark cloud L 723 (19:18:12 +19:36:06) was observed at J, H, and Ks. This was one of the sources observed by Tracy Huard in his analysis of the photometric nonuniformity and is well-suited for this test because of the large number of 2MASS point sources in the field. A 4 × 4 grid of 5sec exposures was used; the integration time was chosen to give reasonable S/N down to H ~ 14 while avoiding saturation of all but the brightest stars in the field. The median sky frame was used for sky subtraction and flatfielding. All 16 fields were individually sky subtracted, flatfielded, and combined using the IRAF upsqiid package.

Only the H band data are presented here. The J and Ks data are available for analysis by the interested reader.

4. Analysis

The 2MASS overlay of the L723 field identified 631 sources with H < 14.0. The IRAF daofind and daophot tasks, with appropriate massaging, were used to obtain aperture photometry of most of these sources using an aperture diameter of 5 arcsec (16 pixels). Some sources were missed due to confusion between closely spaced objects and the degraded image quality on the left side of the array, particularly in the upper left corner (discussed below), leaving about 520 sources with both 2MASS and measured photometry. Since the conditions were not photometric, the photometry was internally calibrated by picking ten random sources between H = 10 and 11.5 and using their average as a zero point.

Figure 1 shows the difference between the measured and 2MASS magnitudes as a function of the brightness. As expected, the scatter becomes larger as one approaches the cutoff at H = 14, and the brightest source clearly shows the effects of saturation. Significant differences are also seen for a number of other stars; some of these are stars near the edge of the field, but a few are unexplained, barring intrinsic variability of the sources.

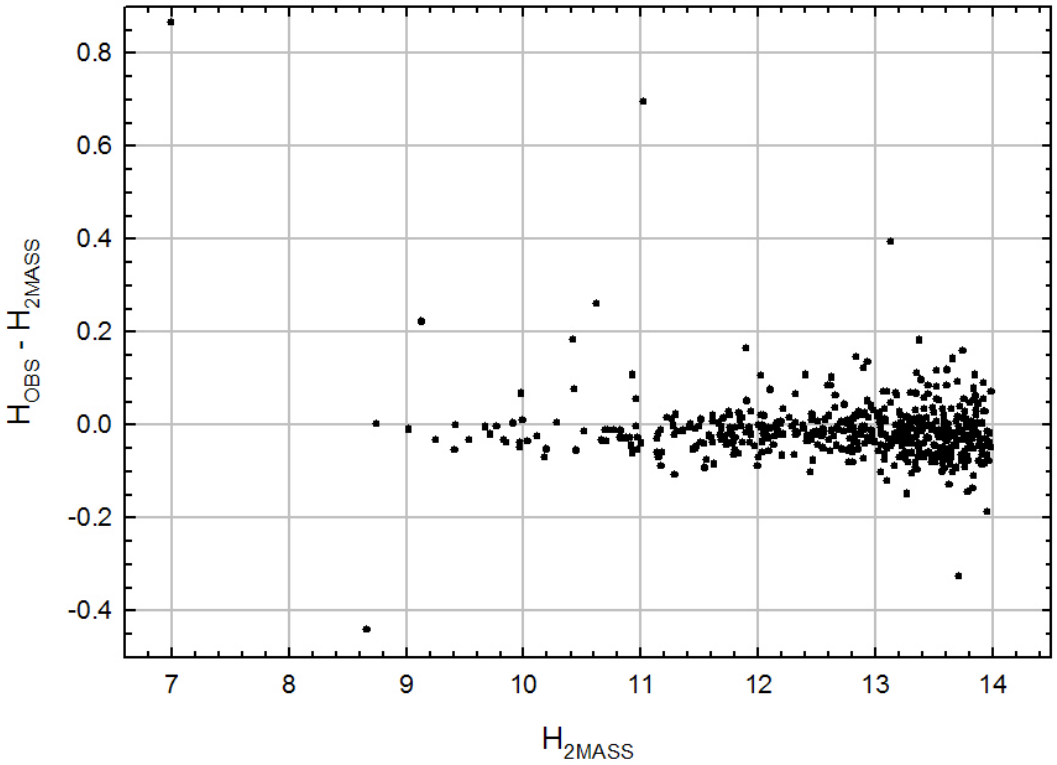

Figure 1: Plot of difference between observed and 2MASS H band magnitudes for sources in L 723.

Plotting the difference in magnitudes as a function of location on the array (Figure 2) does not show any obvious trends, although the 3D scatter plot is difficult to interpret in a fixed geometry.

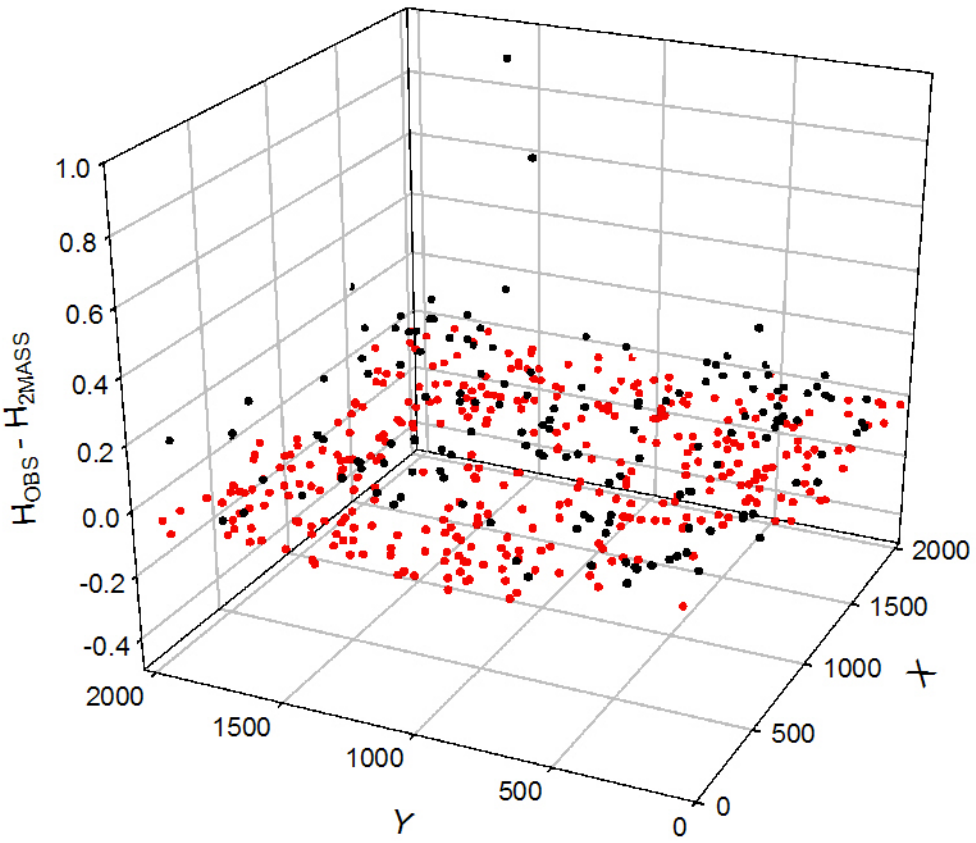

Figure 2: Plot of the difference between observed and 2MASS magnitudes as a function of array coordinates. The black points are positive and the red points negative.

Plotting the data as a contour plot (Figure 3) permits better visualization of the photometric uniformity over the array. The obvious outlying points were removed from the data prior to generating the contour plot, although the effects of some of the errant points near the edges of the array can still be seen. Ignoring the effects near the edge, there are some regions where the photometry appears to deviate by as much as 0.08 mag, although one area near [1800:1200] appears sufficiently sharp that it may be due to a single point with a large deviation.

The encouraging aspect of this initial analysis is that the relatively large regions of very significant (0.3 – 0.5 mag) nonuniformity appear to be absent. This, in combination with the PSF data presented in the first report, suggests that the problem seen in 2004 is no longer apparent.

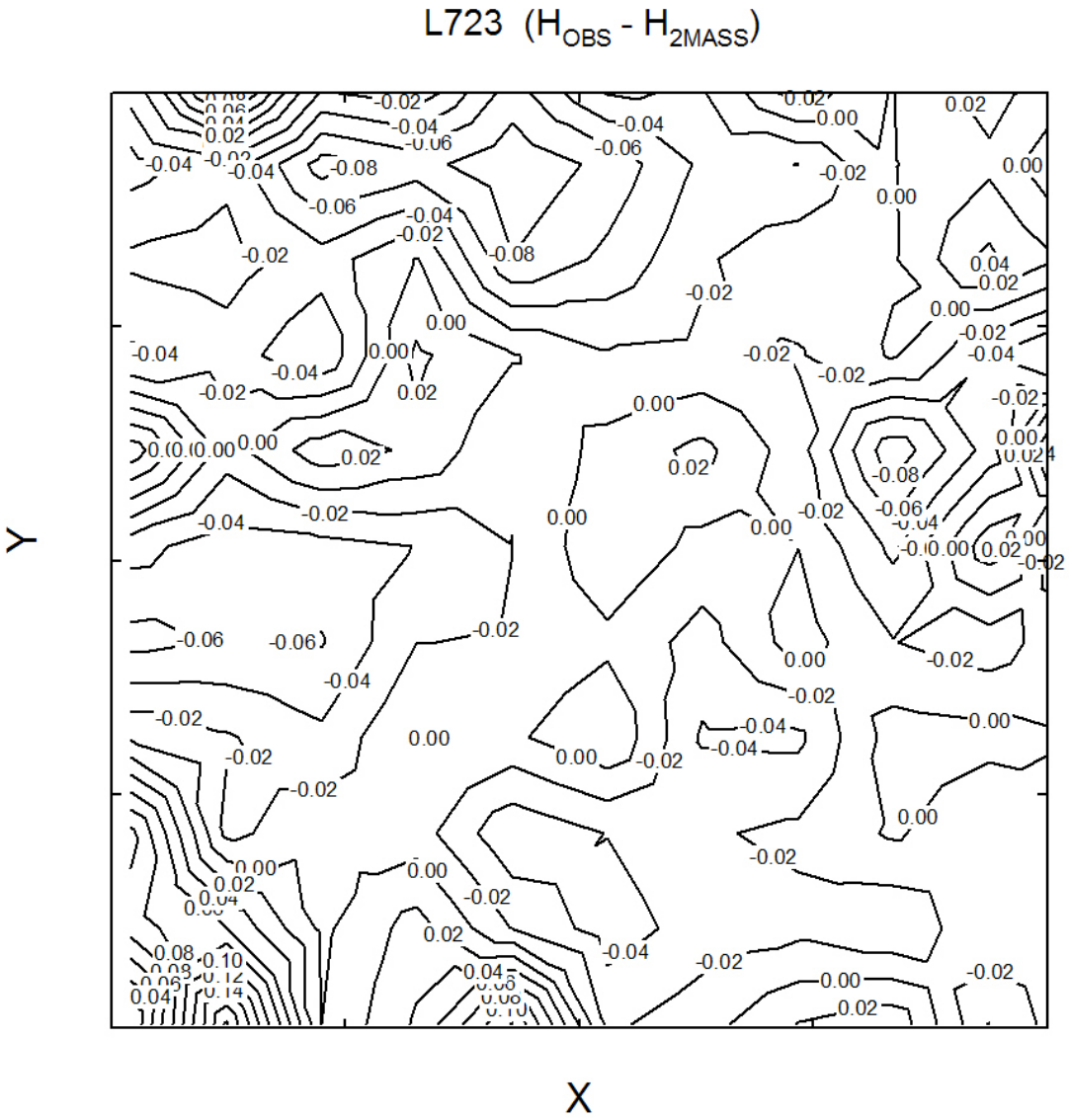

Figure 3: Contour plot of $H_{OBS} - H_{2MASS}$ as a function of position on the FLAMINGOS array. Coordinates are in the raw FLAMINGOS system, with N to the right and E down.

5. Image Quality

The image quality of FLAMINGOS has always been nonuniform over the field, particularly on the left side of the array. The fwscan routine, which is frequently used by observers to determine the best focus, uses the central 1200 × 1200 pixel portion of the array for sampling, so one expects the images near the center of the array to be the best when this focus protocol is employed. Figure 3 shows a 3 × 3 mosaic of subrasters (each 128 × 128 pixels) from the H band image of L 723 arranged according to the region of the parent image from which they were extracted. The focus had been optimized using the fwscan routine, with images near the center of the array having FWHM ~ 2.8 pixels (0.82 arcsec).

The image quality over the center and right portions of the array is quite good, except near the far lower right and bottom, where image FWHM increases somewhat to ~ 3.5 pixels. However, the left side, particularly in the lower and upper left corners shows significant elongation of the images; those in the lower left appear to be to be defocused comatic images, while those in the upper left appear to exhibit a combination of defocus and astigmatism which make them appear double (with the brighter component further off-axis, unlike the comatic images). The details of this structure, such as the doubling of the images, can be seen more clearly in Figure 5, which is a mosaic of contour plots of representative stars from each of the nine subregions.

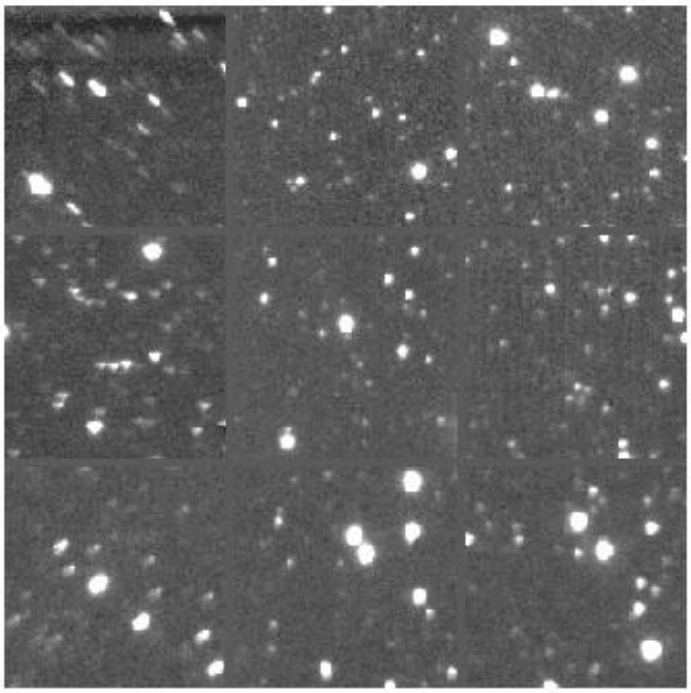

Figure 4: Image subsections (128 × 128) from the L 723 H band image, showing the image quality in nine regions (UL, L, LL, UC, C, LC, UR, R, LR) of the array.

The focus sequence analyzed in the first report suggested that the best focus for the UL and LL regions of the array were at focus settings on opposite sides of that optimized for the array center, but also noted that the seeing was variable on that night. It should be possible to arrive at a compromise focus value which yields quite good images over all but a single corner of the array if this is the case.

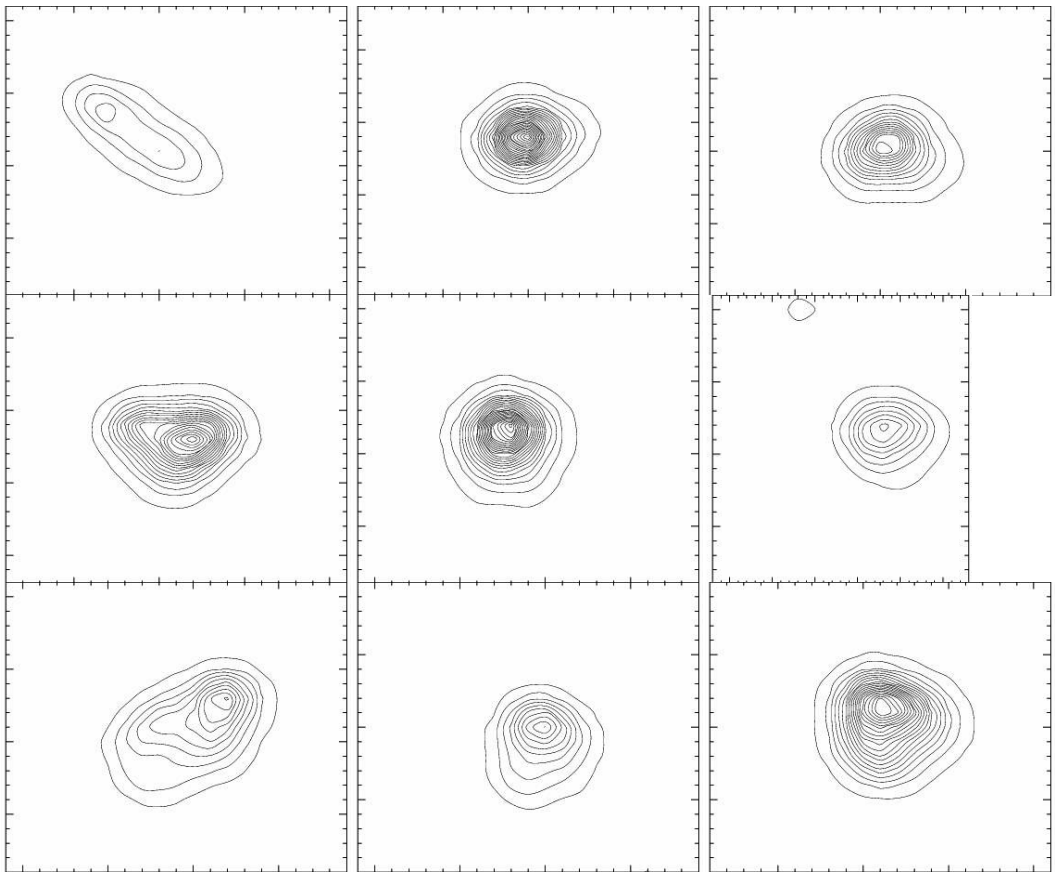

Figure 5: Contour plots of representative stars from each of the nine image subsections (128 × 128) from the L 723 H band image shown in Fig. 4. Each contour plot is 21 pixels on a side, except for the R plot, which was truncated by the edge of the detector.