MORIS Plate Scale Characterization

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Abstract

On the night of June 7, 2011 (Hawaii time), we observed two asteroids with MORIS to measure its plate scale and to measure the coalignment of the MORIS and SpeX/Guidedog fields of view. We measured a plate scale of 0.1141 arcseconds/pixel. The MORIS field center is offset from the Guidedog field center by 6.99 arcsec to the west and 5.02 arcsec to the south. We also saw evidence that the SpeX image rotator may wobble, shifting the image by 3.2 arcseconds after completing a full revolution.

Observations

The observations were carried out by Mike Connelley and Tony Denault, with Paul Sears operating the telescope. We had previously used an asteroid to measure the plate scale of NSFCam2. To use this method, one finds an asteroid with a well established orbit that passes near one or more field stars. The motion of the asteroid is measured in terms of pixels per hour. The ephemeris gives the true motion in arcseconds per hour to high precision. Dividing the two values yields the plate scale in arcseconds per pixel. We found that asteroids 377 Campania and 442 Eichsfeldia would be near the meridian and pass near a suitable field star on the night of June 7th. We took several 5s images of each asteroid, then observed a dense star field (see below), then about an hour after the first observation, observed each asteroid a second time, being careful to keep the asteroid and field star in the field of view. These observations were done with the SpeX field rotator at 0 degrees.

To measure the coalignment of the MORIS and SpeX/Guidedog fields of view, we observed NGC6366, a sparse globular cluster that was near the meridian, to provide a dense star field. A dense field was desired to provide several stars to measure XY alignment as well as rotational alignment. We took images of the cluster simultaneously with MORIS and SpeX/Guidedog to eliminate an effect of the telescope moving between images. These observations were done with the SpeX field rotator at 0 degrees.

We also measured the alignment of the SpeX image rotator with respect to the Guidedog field of view. We used MORIS to guide the telescope on a field star to ensure that the telescope pointing did not change during the observation. We took images with SpeX/Guidedog, rotating the image in 45 degree intervals.

Data Analysis

For both 377 Campania and 442 Eichsfeldia, there were two field stars that were bright enough to reference the asteroid's motion. We measured the pixel coordinates of the asteroid and both field stars in each case.

When taking images simultaneously with SpeX/Guidedog and MORIS, we found that MORIS was about twice as fast. Thus, when taking a set of 10 images in each, there were about 5 MORIS images that were taken at nearly the same time as SpeX/Guidedog images.

To measure the center of rotation of the SpeX image rotator, we measured the position of 4 stars in each of 8 images taken at 45 degree intervals. I used my ncircle.pro program to find the best fit center to the 4 circles made by the 4 stars.

Results

Plate Scale

Figure 1 shows the motion of 377 Campania versus UT, with a linear regression line. Figure 2 shows the deviation of that data from the regression line. The best fit motion is 300.66 pixels per hour. Given that the motion is 37.37 arcseconds per hour, the derived plate scale is 0.11433 arcseconds per pixel. Figure 3 shows the motion of 442 Eichsfeldia versus UT, with a linear regression line. Figure 4 shows the deviation of that data from the regression line. The best fit motion is 333.85 pixels per hour. Given that the motion is 38.02 arcseconds per hour, the derived plate scale is 0.11390 arcseconds per pixel. Averaging these two results together, the final result is a plate scale of 0.1141+-0.0003 arcseconds per pixel.

Observing the asteroid also allowed us to measure how well the array's rows and columns are aligned with the cardinal directions, by comparing the directions of the asteroids' motions from the directions predicted by the emphemerides. The motion of 377 Campania suggests that the sky will appear rotated to a PA of 0.054 degrees, whereas the motion of 442 Eichsfeldia suggests that the sky will appear rotated to a PA of -0.124 degrees. Averaging these two results together, the final result is a rotation of -0.04 +-0.13 degrees.

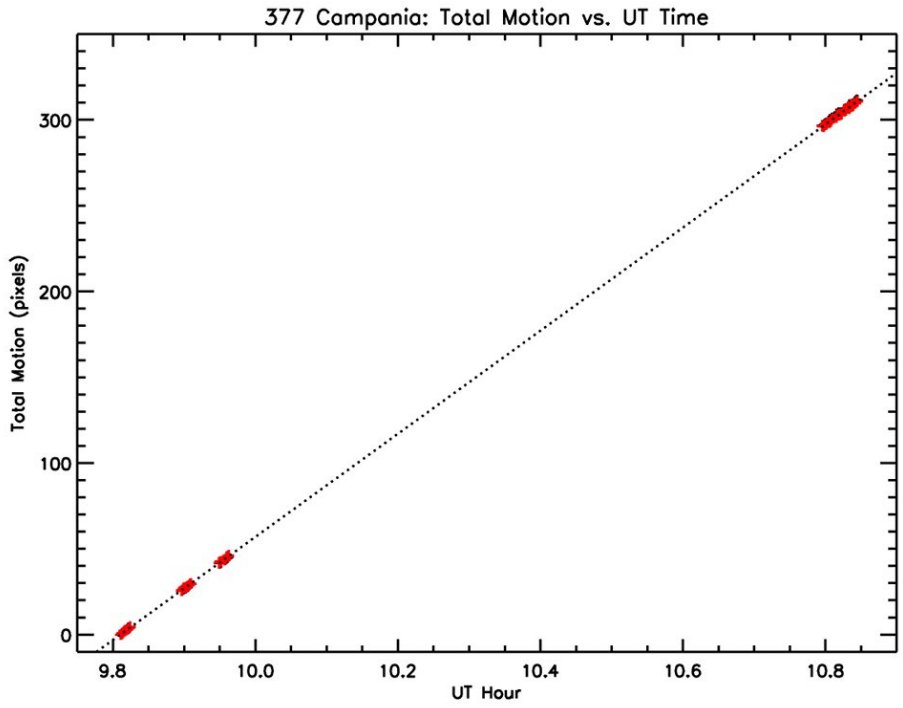

Figure 1: The motion of 377 Campania vs. UT

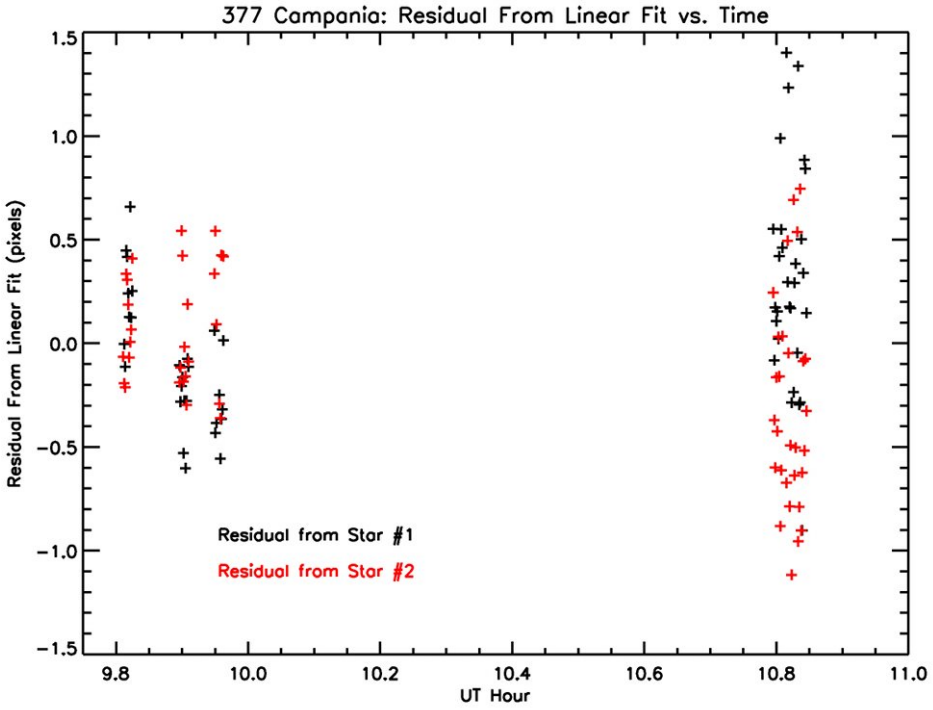

Figure 2: The residual of the motion of 377 Campania from the linear fit.

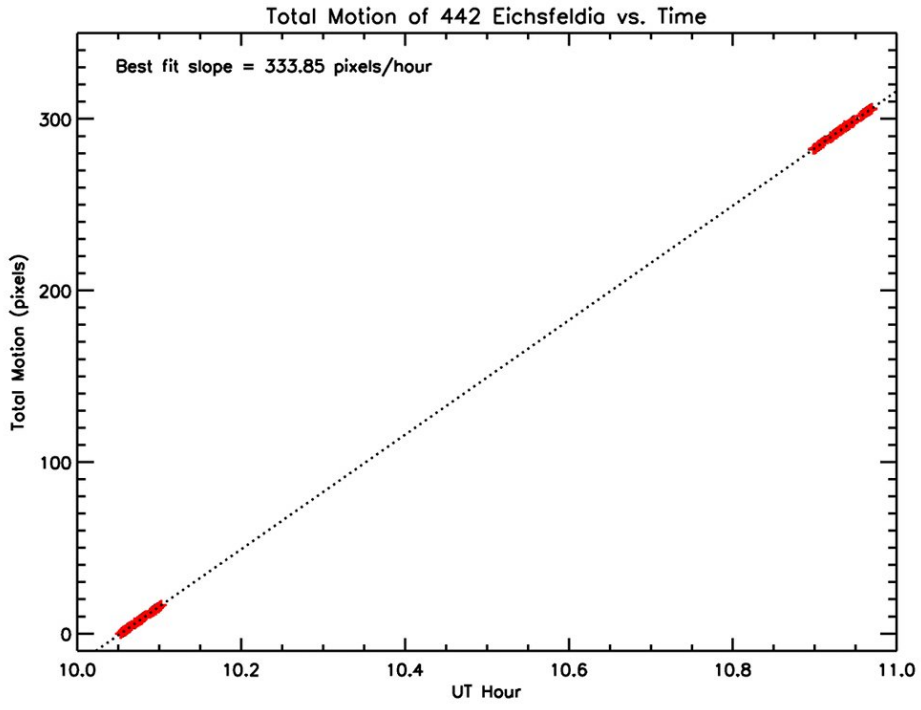

Figure 3: The motion of 442 Eichsfeldia vs. UT

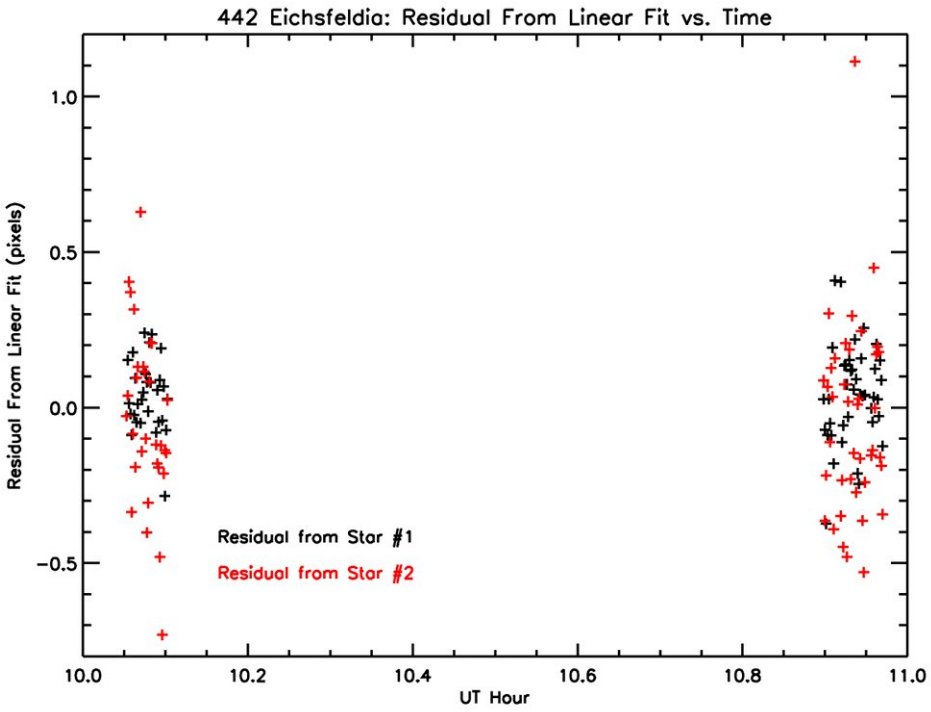

Figure 4: The residual of the motion of 442 Eichsfeldia from the linear fit.

Coalignment

To measure the coalignment of the images, we considered three pairs of images, taken simtaneously with SpeX/Guidedog and MORIS. For each image, we measured the positions of 10 field stars. Relative to the SpeX field center, the MORIS field center is offset by 6.993 +- 0.019 arcsec to the west and 5.018 +- 0.022 arcsec to the south. We also found that there is a 1.2 degree rotation between the fields of SpeX/Guidedog and MORIS. Since we had previously established that the field of MORIS is very well aligned to the cardinal directions, we conclude that the field of SpeX/Guidedog is rotated relative to the sky. Relative to the SpeX field, the MORIS field is rotated to a position angle (PA) of +1.2 degrees. Also, by comparing the astrometry of the field stars, and knowing the plate scale of MORIS, we were able to calculate a plate scale for SpeX/Guidedog of 0.1156 arcseconds/pixel.

SpeX Rotator Alignment

The center of rotation of the image rotator projected onto the guidedog array is at (247.8+-2.4, 248.9+-2.0). After completing a fill revolution of the image rotator, we found that there was an offset between the first set of images taken at 0 deg rotation and the second set. The offset in the field center of (0.70, 27.35) pixels, or (0.08, 3.16) arcseconds. This suggests that the image rotator wobbles slightly, possibly in a non-repeatable way, as it rotates. More data would be required to characterize this.