MMTO Conversion Technical Memorandum #00-4

MMT Observatory

Smithsonian Institution &
The University of Arizona®

Expected Wavefront Errors Due to f/5 Secondary Test Plate

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March 21, 2000

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February 7, 2000

1. Summary

I have estimated the errors in measurement of the MMT f/5 secondary mirror due to figure errors in the test plate. The largest component of measurement error is the combination of slope errors in the test plate and mapping error, a misregistration between pixels in the measurements of the secondary and the test plate. For a conservative estimate of mapping errors, 1% of the mirror radius, the resulting error in the secondary figure over the full mirror amounts to at worst half the specification. The error drops to 40% of the specification when evaluated over the 1.636 m diameter corresponding to a 35 arcminute field. Errors will be further reduced by averaging over several orientations of the test plate. This is an acceptable level of uncertainty in the measurement of the secondary.

2. Background

The accuracy of measurements of the f/5 secondary mirror depends on the accuracy of the holographic test plate, and is limited by two types of errors in the test plate: the computer-generated hologram and the figure of the test plate. Since we measure the figure of the test plate, and subtract it from the measurement of the secondary, this error cancels to first order. The main source of residual error comes from mapping errors in the measurement of the test plate relative to the measurement of the secondary. These mapping errors, in the form of magnification, decenter, rotation and distortion, cause us to subtract incorrect wavefront errors from the apparent secondary figure. The wavefront error is the scalar product of the slope error in the test plate (nm/mm) and the mapping error (mm).

A similar situation exists in measurements of the primary mirror, in which errors in the null lens are measured with a computer-generated hologram, and subtracted from the apparent figure error in the primary. But residual errors are likely to be worse in the case of secondary mirrors, both because the errors to be measured and subtracted are larger for secondaries, and because the test plate is measured with a separate interferometer, with independent magnification, centration, rotation and distortion.

We determine the mapping by placing markers at known locations on the test plate. Their positions in the two images are marked and used to determine the mapping relation. We expect to achieve an accuracy better than 1% of the mirror radius, or 9 mm. Previous measurements have had a resolution of only about 200 points across the mirror, but the new system supports the full resolution of the CCD camera, up to 480 points.

3. Analysis

I simulated mapping errors of three forms—magnification, decenter and rotation—and calculated the resulting wavefront structure function. (Because the worst slope errors are near the edge of the test plate, axisymmetric distortion—which peaks near the 50% zone and is zero by definition at the edge—