



MULTIPLE MIRROR TELESCOPE OBSERVATORY

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MMT UPGRADE/CONVERSION TECHNICAL MEMORANDUM #88-3

Subject: Optical Performance of an f/9 Chopping Secondary

From: D. Blanco

Date: June 28, 1988

This memo examines the possibility of an f/9 focal ratio chopping secondary for the MMT Upgrade/Conversion optical system described in memo #88-1 of this series. The attached sheets show the optical performance of an f/9 secondary as it is chopped about its vertex through 0, 5, 10, and 20 arcseconds of throw. Rms image diameters and spot diagrams are given for images at 19 points in a 2 arcminute (1.34 inch) diameter field. For this size field there is negligible difference between the images on a medial (best curved) image surface or on a flat cut through the focus. The aberrations are slightly (about 1%) improved if the chopper pivot point is moved from the vertex to the secondary center of gravity.

At a wavelength of 10 microns, a 6.5 meter aperture telescope will be limited by diffraction (2.44λ) to about 0.77 arcsecond diameter images. The diameter of 100% encircled energy for the comatic image induced by chopping is about 1.14 times the rms diameter, so the f/9 system will be diffraction limited for aberrated images of about 0.68 arcseconds rms diameter. This corresponds to about 20 arcseconds of chopper throw without allowance for miscollimation.

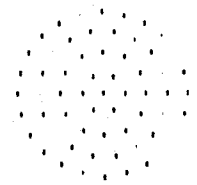
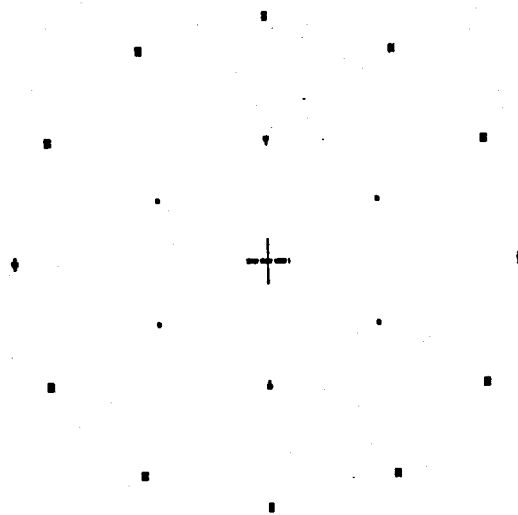
For IR use the secondary chopper should be undersized to exclude radiation from the edge of the primary. For this system the secondary should be about 34.5" in diameter. Assuming an aspect ratio of 8 and 80% lightweighted construction, this mirror will weigh about 70 pounds. A central hole may be desirable to reject radiation emanating from the primary Cass hole and to further lightweight the mirror. With associated supports the entire chopping mass will be about 130 lbs., and the polar moment of inertia 25 in lb sec²/rad. If we allow a maximum 1.5 gravity acceleration at the mirror edge, the allowable angular acceleration is 5.35 rad/sec².

For a 20 arcsecond throw on the sky, the secondary must move 3.67 times this, or 73.4 arcseconds of secondary motion. Accelerating from a dead stop through 73.4 arcseconds to maximum speed will take 0.0115 seconds, and a similar amount is required to decelerate to a dead stop for a full travel time of 0.023 seconds. Allowing a 60% duty time, the theoretical maximum chop rate is 29 Hz. A real servo might be expected to achieve half this, or about 14.5 Hz for 40 arcseconds full throw and 60% duty cycle. Bob Nagel estimates the system will be power limited to about 10 Hz with 100 watts dissipation.

A word about the illustrations: The spot diagrams are shown at a scale magnified over their positions on the page--rather like examining a plate with a magnifier. The scale for the images is indicated by the one arcsecond disk to the right of the spot diagrams. This disk also shows the set of points in the pupil plane used to generate the spots in the focal plane. The pupil points are arranged in a hexapolar grid. This causes some difference in the appearance of the spot diagrams from other ray trace programs (such as SODA and Code V) which use a square pupil grid.

IMAGE SIZES IN ARCSECONDS RMS FOR AN 1/ 1.2 TO 1/ 9 MISMATCHED CASSEGRAIN
 FLAT IMAGE FIELD FOR CX = 0 CY = 0 , VX = 0 VY = 0
 SKY CHOP ANGLE = 0 ARCSECONDS 2 ARCMINUTE DIAMETER FIELD

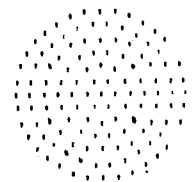
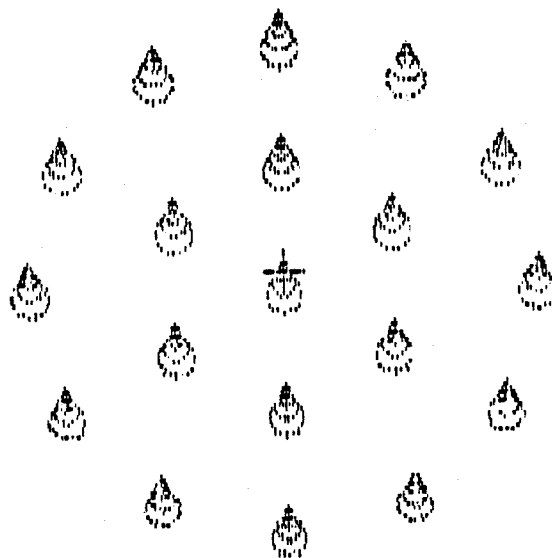
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2.165604E-02		2.165604E-02
2.165604E-02	1.014349E-02	2.165604E-02
	1.014349E-02	1.014349E-02
2.165604E-02	1.815245E-02	2.165604E-02
	1.014349E-02	1.014349E-02
2.165604E-02	1.014349E-02	2.165604E-02
	2.165605E-02	2.165604E-02
	2.165604E-02	



1 ARCSECOND

IMAGE SIZES IN ARCSECONDS RMS FOR AN f/ 1.2 TO f/ 9 MISMATCHED CASSEGRAIN
 MEDIAL IMAGE FIELD FOR CX = 0 CY = -8.592383E-03 , VX = 0 VY = 0
 SKY CHOP ANGLE = 5 ARCSECONDS 2 ARCMINUTE DIAMETER FIELD

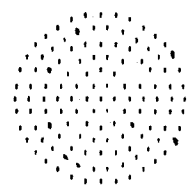
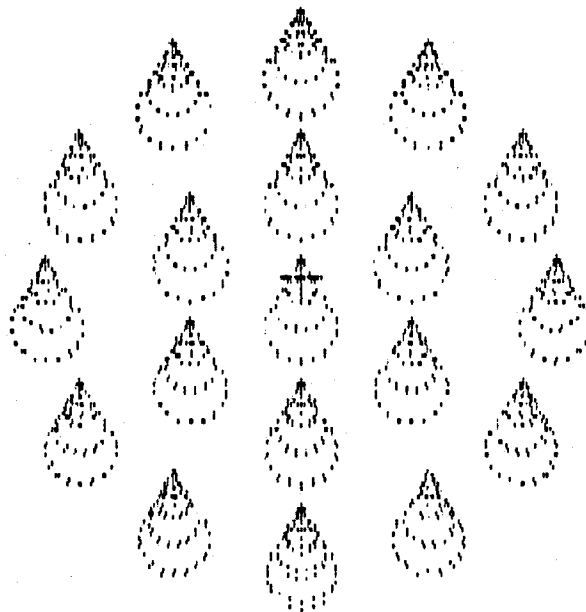
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 .1816274 .1816274
 .1782534 .1780186 .1782534
 .1756794 .1756794
 .1736049 .1732516 .1736049
 .1709636 .1709636
 .1689072 .1685858 .1689072
 .1654348 .1654348
 .1641564



1 ARCSECOND

IMAGE SIZES IN ARCSECONDS RMS FOR AN $f/1.2$ TO $f/9$ MISMATCHED CASSEGRAIN
FLAT IMAGE FIELD FOR $CX = 0$ $CY = -1.71847/E-02$, $VX = 0$ $VY = 0$
SKY CHOP ANGLE = 10 ARCSECONDS 2 ARCMINUTE DIAMETER FIELD

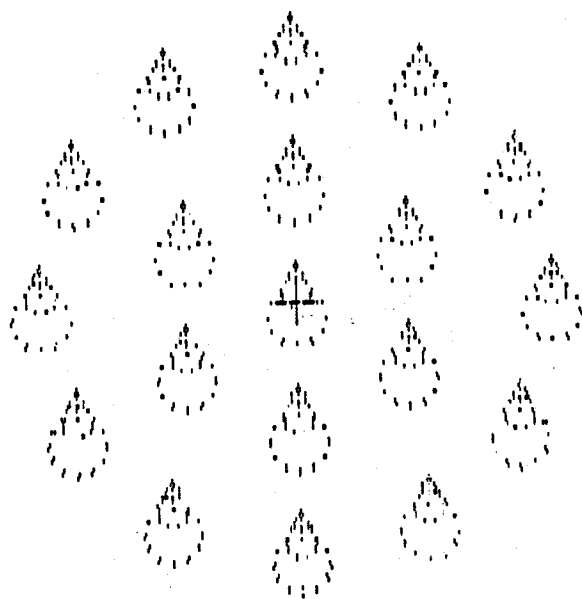
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.3548542		.3548542
.3516391	.3515361	.3516391
	.3490718	.3490718
.3473317	.3468969	.3473317
	.3442065	.3442065
.3431254	.3418063	.3431254
	.3401127	.3401127
	.3390243	



1 ARCSECOND

IMAGE SIZES IN ARCSECONDS RMS FOR AN F/ 1.2 TO F/ 9 MISMATCHED CASSEGRAIN
MEDIAL IMAGE FIELD FOR CX = 0 CY = -.8/26639 , VX = 0 VY = 0
SKY CHOP ANGLE = 20 ARCSECONDS 2 ARCMINUTE DIAMETER FIELD

.7028413
.7014926 .7014926
.6979069 .6977896 .6979069
.6954058 .6954058
.6932449 .6930436 .6932449
.6908454 .6908454
.6888607 .6886698 .6888607
.6858307 .6858307
.6847601



1 ARCSECOND