



MULTIPLE MIRROR TELESCOPE OBSERVATORY

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MMTO Technical Memorandum 82-19

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Subject: Pathlength Adjustments in MMT on the basis of the October 1, 1982 measurements

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- (1) On October 1, 1982 I used the new (x,y) beamcombiner stage (MMTO Technical Memo 82-14) to equalize the pathlengths of pairs of MMT telescopes with telescope B as the common element in all pairs. Atmospheric dispersion effects were removed with the Hege speckle prism system which is inserted in front of the image. The detection system used was the Differential Speckle Interferometer which looks at the image on the z axis of the telescope. We used no filter so the spectral range covered was determined by the detector (400-850 nm) and the color of the star (α CYG A2I). For all practical purposes we were looking for a set of ≈ 5 "white light" fringes in the center of the speckle image. These fringes, when phased, were stunningly apparent. They could easily be centered on the center of the field of view to an accuracy of a couple of micron motion of the beamcombiner.
- (2) To phase telescopes B & E I set the beamcombiner at the nominal zero positions of the beamcombiner (x = Azimuth = 303, y = elevation = 273) and moved the beamcombiner in the y direction to obtain the white light fringe. This occurred at x = 303, y = 168 (telescopes B and E focus readouts were 2378 and 1669). From MMTO Technical Memo 82-14 this means that I moved the beamcombiner down (towards E) over 2.51 mm. (NOTE: W. Davison tells me that the accuracy of the potentiometer is not good so that these numbers may be good only to a few percent). To convert this number to a pathlength P difference between the telescope for the undisplaced beamcombiner, one has to take account of the geometry of the beams incident on the beamcombiner as well as the offset pointing of the telescope which was needed to bring the image back on axis (since both images B and E move when the beamcombiner is displaced). As a result we find that with a centered beamcombiner
$$P_E - P_B = 2.143 \times 2.51 = +5.38 \text{ mm}$$
- (3) To phase the other 4 telescopes to B, I returned the beamcombiner to its nominal zero position and then moved it from there in azimuth. This motion leaves the pathlength and image position of B unchanged, but it moves both for the other telescope in the pair. The image motion was corrected by tilt of the secondary. The following table summarizes the measurements:

Telescope	Focus	Phased at x =	P-P _B
A	1955	233	-1.68 mm
C	2510	93	+5.05 mm
D	1931	311	-0.19 mm
F	2170	649	+8.31 mm

- (4) To compensate for these pathlength differences we need to move the tertiary mirrors up (+) or down (-) by the following amounts:

Telescope	Motion in z
A	-1.70 mm
B	0.00 mm
C	+5.12 mm
D	-0.19 mm
E	+5.48 mm
F	+8.43 mm

(Note small correction for focus adjustment). The tertiary mirror tilts will need a small adjustment to bring the image back on axis.

- (5) I measured the change of pathlength difference between telescopes B and E as a function of elevation both with the telescope going up and going down. While doing this the TCS open-loop correction to the MMT secondaries were functioning. Since the corrections to the B and E secondaries are similar and of the same sign, this introduces a systematic change in $P_E - P_B$ because of telescope pointing errors. It would have been better to not use the TCS open-loop for this experiment, to adjust the telescope pointing to divide the pointing difference between telescopes B and E equally, and to touch up the remaining misalignment by adjusting the secondaries. As it is, I will correct below for the error introduced by the average TCS open-loop correction. I have two sets of measurements, one going up, one going down. The zero points of the two are not related.

GOING DOWN

EL	Beamcombiner Motion	Relative $P_E - P_B$	Pointing Correction	Corrected Relative $P_E - P_B$
77°19'	≡ 0 μm	≡ 0 μm	≡ 0	≡ 0 μm
70°25'	17 μm	- 37 μm	+ 35 μm	- 2 μm
59°12'	45 μm	- 100 μm	+ 89 μm	- 11 μm
48°56'	59 μm	- 131 μm	+ 139 μm	+ 8 μm

GOING UP

EL	Beamcombiner Motion	Relative $P_E - P_B$	Pointing Correction	Corrected Relative $P_E - P_B$
48°56'	$\equiv 0 \mu\text{m}$	$\equiv 0 \mu\text{m}$	$\equiv 0$	$\equiv 0 \mu\text{m}$
57°00'	13 μm	+ 29 μm	- 40 μm	+ 11 μm
67°11'	42 μm	+ 93 μm	- 90 μm	+ 3 μm
72°00'	48 μm	+ 108 μm	- 113 μm	- 5 μm

The relative pathlength change with elevation is therefore very small. The variations between the two sets may be indicative of the measurement accuracy although the measurement errors appeared to be less ($\pm 5 \mu\text{m}$) at the time of the data taking. From the data above I obtain

$$d(P_E - P_B)/dEL = + 0.3 \pm 0.6 \mu\text{m/degree}$$

- (6) We will make the tertiary height adjustments given in (4) in December 1982 so that I can check the corrections during the DSI run at the end of December.