

MULTIPLE MIRROR TELESCOPE OBSERVATORY

TECHNICAL REPORT NO. 5

THE TELESCOPE COALIGNMENT SYSTEM
FOR THE
MULTIPLE MIRROR TELESCOPE (MMT)

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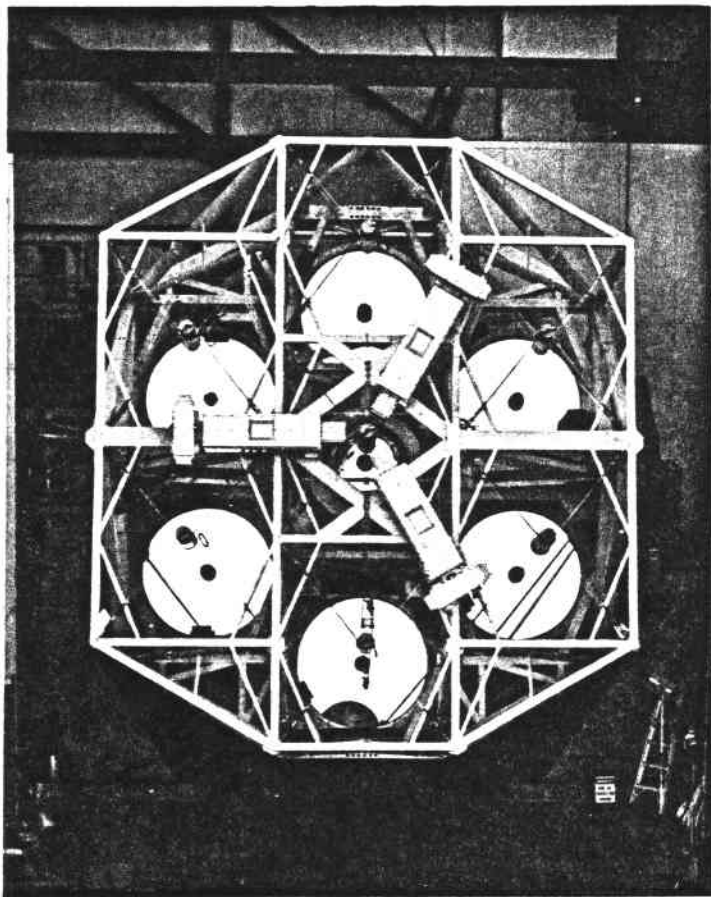


ABSTRACT

This paper describes the coalignment system for the six 1.8 m astronomical telescopes of the Multiple Mirror Telescope. Emphasis is on individual component alignment and the achievement and maintenance of particular image configurations. The system employs a HeNe laser as an artificial star with its light collimated by a 0.7 m guide telescope and transferred to the 1.8 m telescopes via periscopes and retroreflectors. Silicon detectors sense laser image position deviations due to mirror tilts or displacements, and generate signals to actively correct pointing errors via 3 axis motion of the telescopes' cassegrain secondaries. Procedures are given for aligning the laser beamsplitters, collimating the beams, and aligning the detectors sequentially to arrive at a desired configuration. Keys to the operation are the use of a pinhole in the guide telescope's focal plane as a defining point for the laser source, the active stabilization of the guide telescope's focus, the stability of the periscopes, and the use of remotely-controlled thin wedge prisms to change each laser beam's position when reconfiguring any one telescope. Tests of star tracking show typical coalignment to <1.0 arc second RMS. A discussion of problems encountered is included.

I. INTRODUCTION

The MMT, located in Southern Arizona on the top of Mount Hopkins (8550 ft.), has been described by Carleton and Hoffmann¹. Briefly, the MMT consists of six 1.8 m cassegrain telescopes grouped in a hexagon, plus a 0.7 m guide alignment telescope (G/A telescope) of Ritchey-Chretien design at the hexagon's center, all held in a complex truss system (the optical support structure or OSS) which rides on an altitude over azimuth mounting.



Images from the 1.8 m telescopes are combined via two extra reflections per telescope. A laser coalignment system is used to keep telescope images superimposed.

Image position and focus are controlled by 3 axis secondary mirror motions. An X tilt moves images horizontally, a Y tilt moves images vertically, and a Z translation changes focus. Active control is necessary because the OSS flexes due to elevation angle changes from 90° to 0° and temperature changes of up to 20°F in 4 hours.² Errors in image position and focus result-

Figure 1.
The Multiple Mirror Telescope
ing from OSS flexure are sensed and fed back to secondary actuators for correction. Error sensing is accomplished by a laser system which introduces laser beams into the edges of the telescopes' apertures and detects mirror motions via silicon detectors near the composite image plane. (See Figures 2 and 3.)

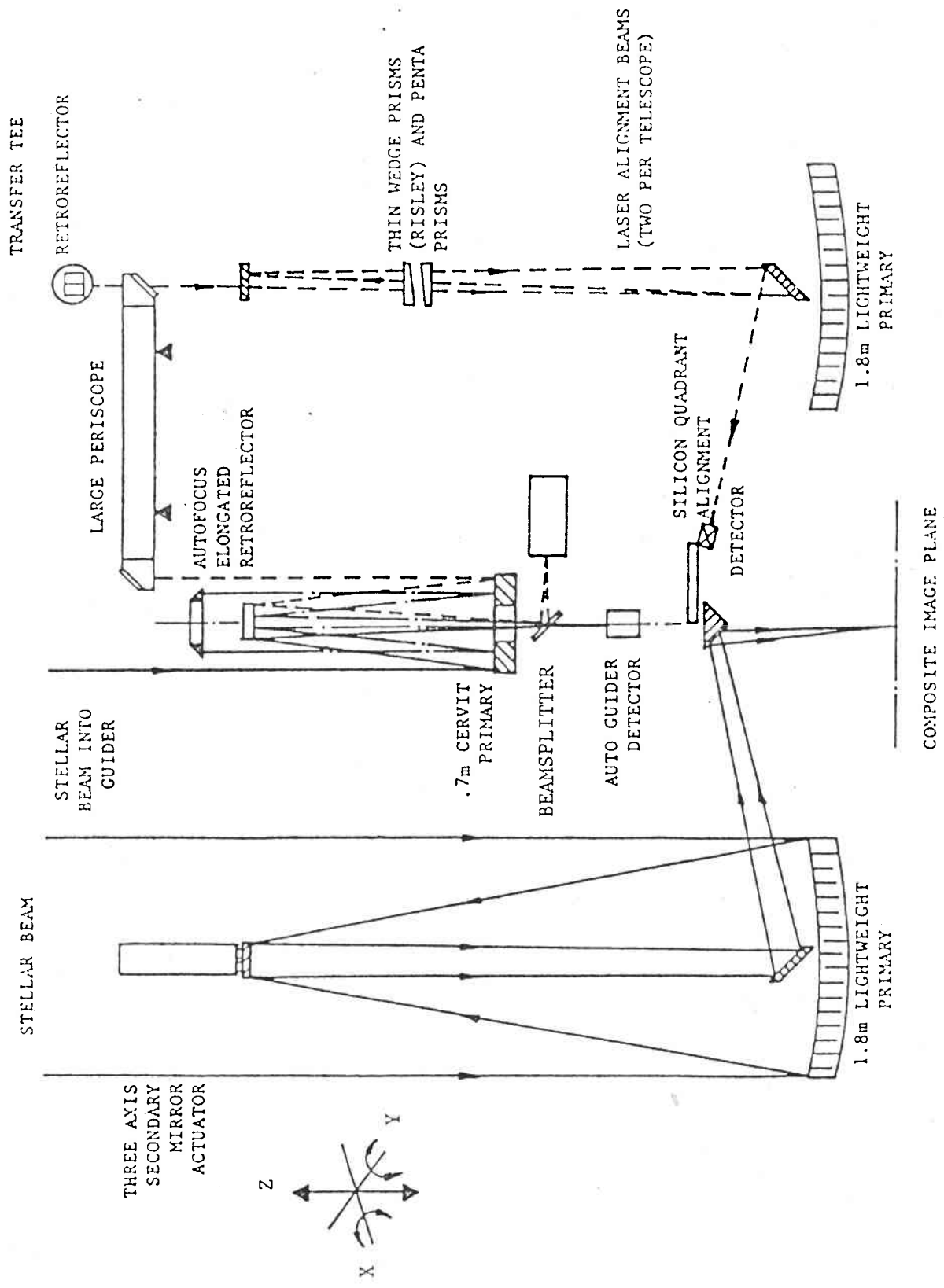


Figure 2. Coalignment system optical paths.

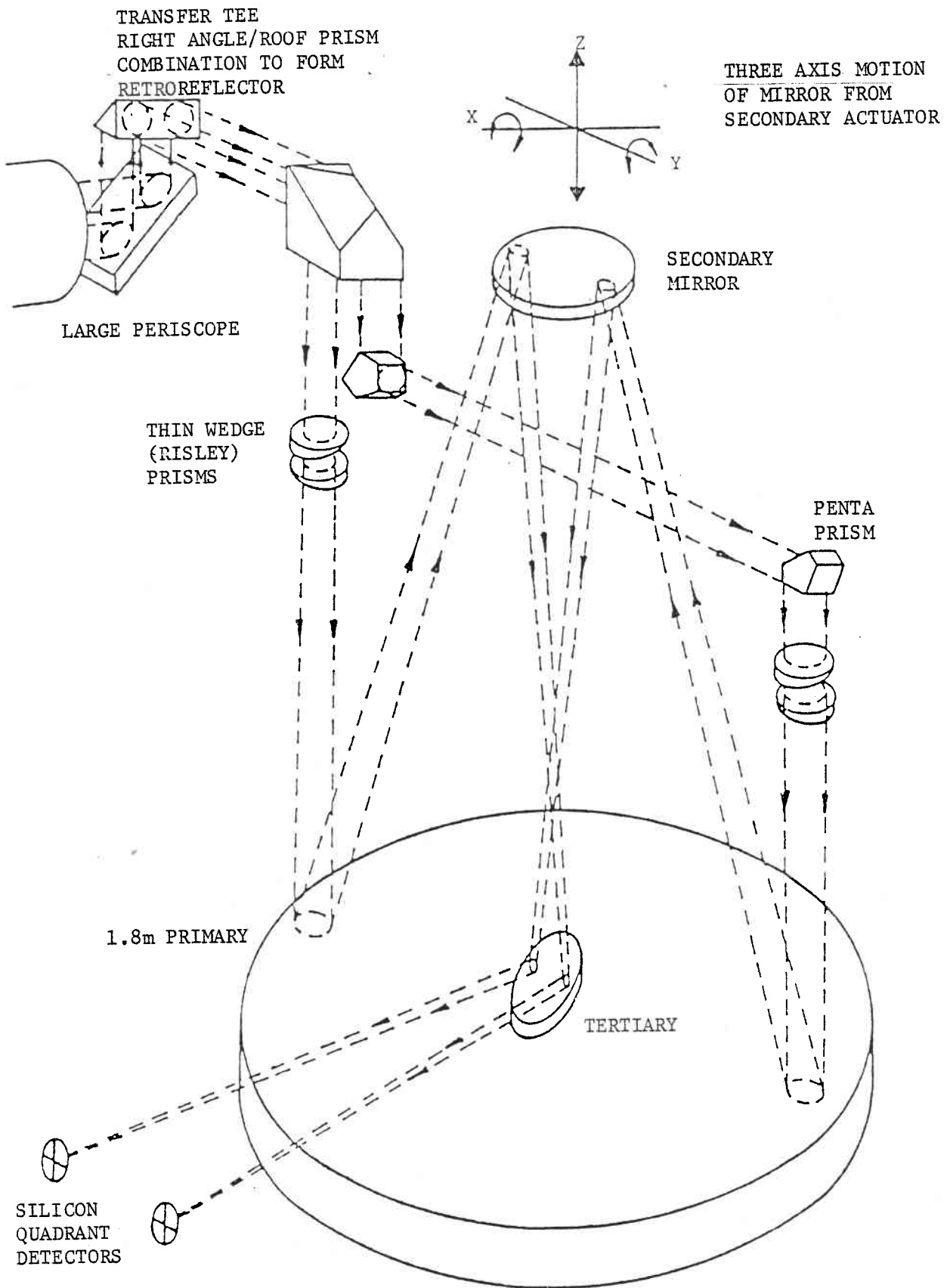


Figure 3. Laser alignment beam optical paths.

II. LASER SYSTEM

The output of a HeNe laser is modulated at 1 KHz by a Pockels cell. An optical beamsplitter arrangement separates the single beam into three parallel beams whose separations form an equilateral triangle. These three beams are focused through a pinhole in the focal plane of the G/A telescope and then collimated by the G/A mirrors. They fill three periscope entrance apertures which project over the G/A aperture. Each periscope feeds light to two of the 1.8 m telescopes through a cross tee (a pair of retroreflectors) on its end. The resulting 6 laser beams are parallel in direction to the G/A pointing axis and provide an internal reference for telescope coalignment.

In each 1.8 m telescope, half the laser beam is deflected to the opposite side of the 1.8 m aperture by a pair of pentaprisms. The two resulting beams enter opposite edges of the 1.8 m aperture. Two pairs of thin wedge (Risley) prisms deviate these beams slightly beyond the edge of the field of view where each strikes a silicon quadrant detector. With two beams, there is sufficient information for a simple analog circuit to extract focus and tilt information and feed it back to the secondary actuators for focus and tilt adjustment of each telescope.

III. OVERALL SYSTEM SPECIFICATIONS

It is convenient to consider star images in the composite image plane. Changes in elevation, temperature, and temperature gradients across the telescope were analyzed and expected to produce maximum pointing errors (equivalent to image motions) of 0.75 arc seconds per minute** with a total range of < 140 arc seconds.² To provide the capability of achieving many different image configurations, the secondaries may be tilted to produce $\pm 0.86^\circ$ of image plane motion. Z-axis motion provides a focal range of

**The plate scale for converting angles to linear distances in the composite image plane is 0.26 mm per arc second.