

MMTO TECHNICAL REPORT NO. 10

MMT SEEING EXPERIMENTS
IN 1980

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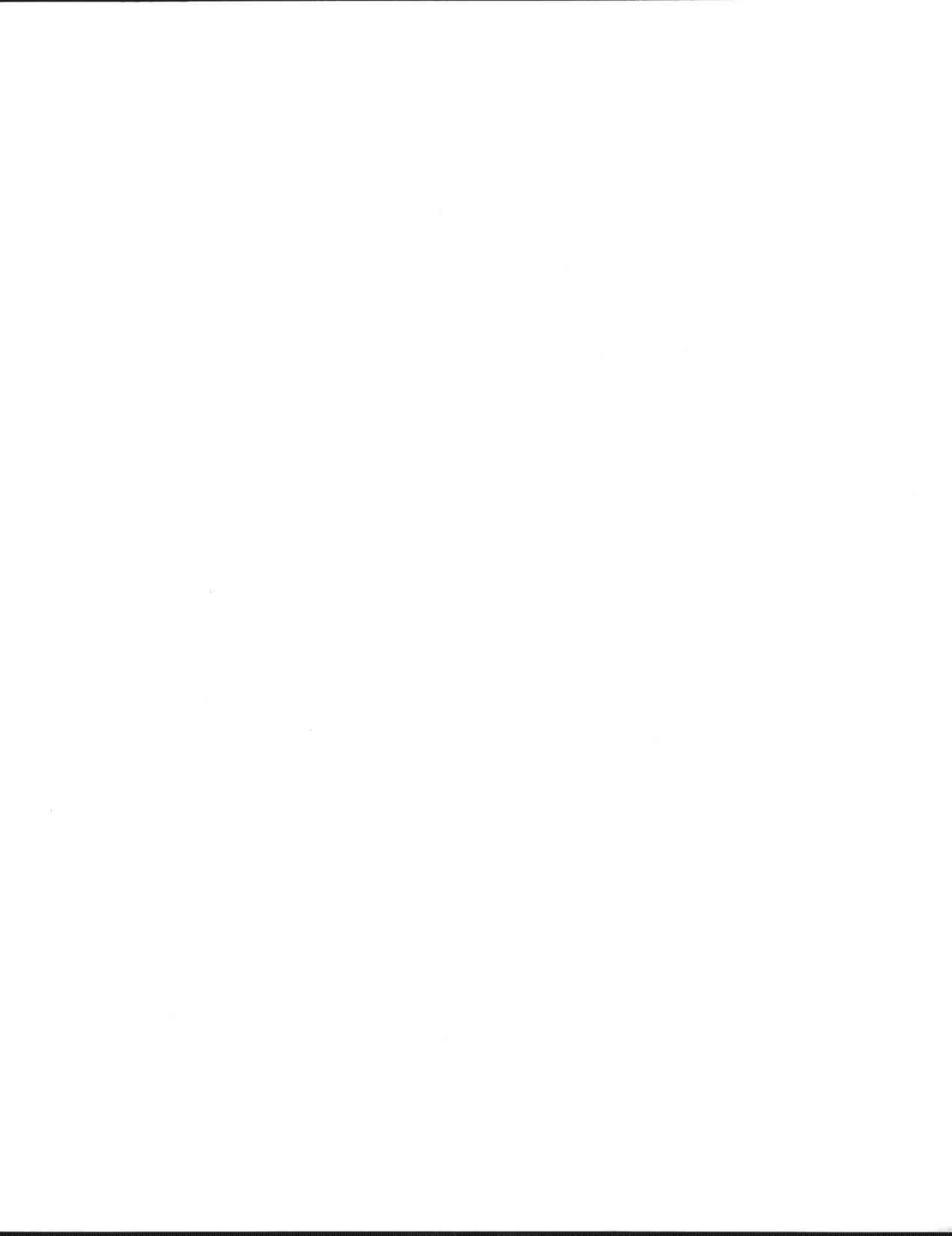
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ABSTRACT

This report summarizes a number of experiments which were carried out at the MMT in 1980 aimed at improving the image quality of the telescope. They include thermal and optical measurements, as well as thermography of the telescope, building and environment. A number of suggestions for future improvements are made.



1. INTRODUCTION

In 1980, the first full year of MMT operations, we undertook a number of studies related to astronomical seeing. As of the date of this report, we know that MMT image quality rivals that of any other astronomical telescope in the world. We also know, however, that many of the residual seeing effects reside in the MMT building. In 1980 we identified a number of seeing sources, and we eliminated some of them. Specifically, by insulating the floor and the telescope yoke, as well as by drawing chamber air through the yoke into the lower part of the building and out, we have eliminated the effects of these two components. Other sources of seeing, however, remain which we plan to minimize in 1981. It is important to reduce astronomical seeing not only for direct stellar observations, but also to reduce seeing effects on the laser coalignment system and on possible future telescope cophasing arrangements.

In this report we summarize the observations made in 1980 using laser image variations, thermal sensors, and thermography. In 1981 we plan to reduce effects resulting from the heating by electronic components on the MMT, from heating from the sides of the MMT chamber, and from the cooling of the Optical Support Structure and the MMT shutters by radiation.

2. LASER COALIGNMENT SIGNAL

The design of the MMT included a coalignment system based on an artificial laser "star" generated by the central MMT Guide-Alignment telescope. This star is fed into the six main telescopes by means of transfer optics (the so-called "periscopes") and imaged into a laser "star" image whose diameter of six arc seconds is determined by diffraction on the 25 mm aperture used. The position of the laser image is measured by a quad-detector. It is used to coalign the telescopes. Appendix A is a MMTO Technical Memorandum which discusses the performance of this laser coalignment system. In these tests there were two kinds of coalignment variations, slow ones (hours) resulting probably from flexure in the transfer optics and telescope optics, and fast ones (fraction of seconds) which I believe to be caused by internal seeing. The fast motions of the stellar images, called "dancing" in the report, were the direct result of rapid error signals being fed in the coalignment servo. Decreasing the gain of the servo slowed the motions down, but did not reduce them to zero. At the lowest gain (time constant ~ 2 sec), the motions still amounted to ~ 0.3 arc seconds RMS in both axes. The error signals when examined directly show a very rapid fluctuation (> 10 Hz) which is due to electronic noise and a relatively slow variation (0.5 - 5 Hz) which is seeing-related. Decreasing the laser light level lowers the slow variations, but not the rapid ones as is to be expected.

I also studied the motion of the laser beams photographically with short exposure times (1/8 sec) and 10 second intervals. The results are described in the Technical Memorandum copied in Appendix B. The RMS motions of the images amounted to ~ 0.6 arc seconds confirming the photo-

electric results (considering the smaller time constant). Comparing the motions in different telescopes I also concluded that: (i) most of the motions originate in the main telescopes rather than the guide-alignment telescope, (ii) all telescopes showed comparable size motions eliminating the possibility of one single, isolated seeing source, (iii) the schlieren size causing the motions was less than 24 inches since the motions of adjacent laser beams are uncorrelated. It is also larger than 1 inch since the diffraction patterns of the laser images did not vary.

From these experiments with the laser coalignment system, I concluded that internal seeing at the MMT very significantly affects the image quality as well as the coalignment of the telescopes. The coalignment problem can be overcome by time averaging of the laser error signal over about one minute which should make it accurate to about 0.1 arc seconds. The new Telescope Coalignment System will do that.

3. INTERNAL VERSUS EXTERNAL SEEING

In Appendix B, I estimate the effect that laser seeing has on the stellar image quality using a geometrical optics approximation. We think of the telescope aperture being divided in separate sub-aperture elements of diameter D over which the wavefronts are flat but tilted, thus causing an image displacement equivalent to the RMS laser motion σ . From the previous section $1 \text{ inch} < D < 24 \text{ inches}$. The stellar image broadening due to internal seeing can then immediately be derived. Assuming a normal distribution for the image displacement, it corresponds to a gaussian with a FWHM (full width at half maximum) of 2.35σ . For the observations described in Appendix B, most of the stellar

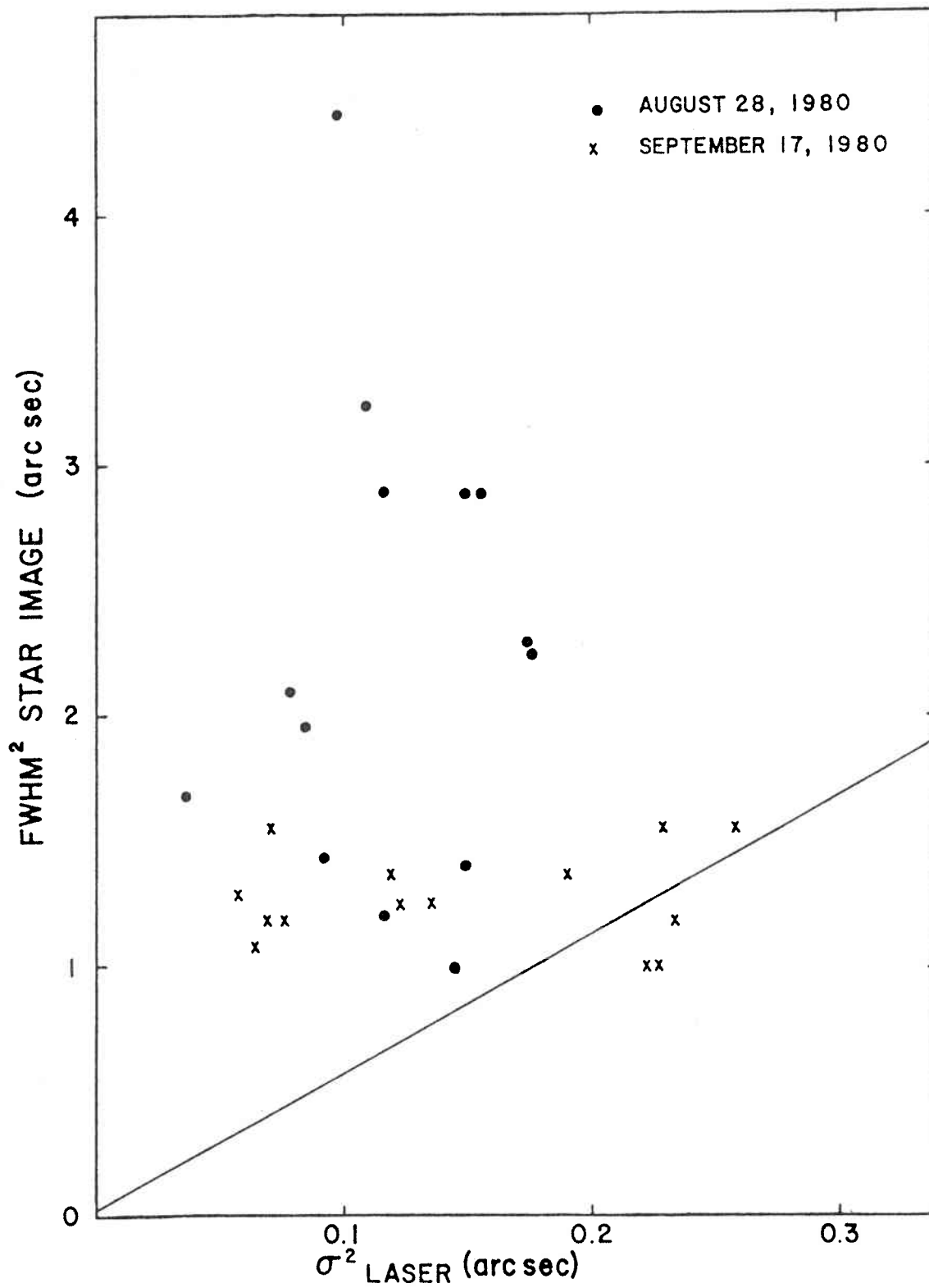


Figure 13