

MMTO TECHNICAL REPORT NO. 9

THE MULTIPLE MIRROR TELESCOPE

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1. INTRODUCTION

On May 9, 1979 The Multiple Mirror Telescope, or MMT, was dedicated. The MMT is located in Arizona on the top of Mount Hopkins ($110^{\circ} 53' 04''.4$ longitude, $31^{\circ} 41' 19''.6$ latitude) at an elevation of 2600 meters, a site which was selected because of its general location in the astronomically active Tucson area, but more so because of its good seeing and photometric properties, because of its reasonably high altitude making it a dry and relatively dark site, and because of its large number of clear nights. The MMT was conceived in the late 1960's when scientists at the Smithsonian Astrophysical Observatory and at the University of Arizona decided to use six existing 1.8 m "egg crate" mirrors to construct six parallel Cassegrain telescopes whose images were to be combined into one, by so-called beamcombining optics. In this way they would effectively create a telescope with a combined collecting area equivalent to that of a 4.5 m diameter single mirror, thus making it, in that sense, the third largest optical telescope in the world. It was primarily the need for this large collecting area which motivated the decision to construct the MMT. The telescope was designed to be optimal for both optical and infrared astronomy of faint and low contrast objects. The large edge to edge distance in the primary mirror assembly (6.9 m) created in addition the opportunity to do very high resolution imaging, both at infrared and optical wavelengths using, for example, Michelson and speckle interferometry.

Figure 1 gives a general overview of the Mount Hopkins site. The telescope is located on a relatively small flattened top of a rather

sharply peaked mountain. This places it effectively high above the general surroundings. This we believe is, in addition to the design of the building and telescope itself, the origin of the very good image quality obtained with the MMT. Within our limited observing experience the average image quality is about one arc second (full width at half maximum of seeing disk) with images of 0.5 arc second being recorded rather frequently. Figure 2 shows a closeup of the telescope itself. It is supported by an altitude over azimuth mount which, under computer control, can track objects at both sidereal and non-sidereal rates. The telescope axes use ball bearing supports rather than the conventional pressurized hydrostatic bearing support. They are driven by a torque motor-pinion gear arrangement rather than by the traditional worm gear. The alt-azimuth mount cradles the optical support structure (OSS) which contains the six 1.8 m Cassegrain telescopes, the beamcombining optics as well as the 76 cm Cassegrain-guide/alignment telescope, and which was designed to provide the required stiffness at a minimum cost in weight. The telescope and its mount is located within a building which corotates with the telescope azimuth. This building, in addition to housing the telescopes, contains the telescope control room, the data collection and analysis room, workshops, a conference room and offices.

The optical paths in the MMT is shown in figure 3. Each Cassegrain telescope has a $f/2.72$ 1.8 m diameter primary mirror. The secondary mirror changes the beam to a $f/31.6$ focal ratio which is transferred via a flat tertiary mirror and beamcombiner to the MMT's

quasi-Cassegrain focus located on the central axis of the OSS. The image scale there equals 3.6 arc seconds/mm. The steepness of the facets of the beamcombiner determines the "final f-ratio" of the MMT which is defined by the envelope cone of the six converging beams. The angle of this cone and the size of the unvignetted field of the MMT are related. For the existing f/9 beamcombiner, this field equals 52 arc seconds. Vignetting sets in slowly, however, so that the MMT has a "useful field (< 50% vignetting) of 4 arc min. A "faster" beamcombiner will increase the field of view at the cost of a lower filling factor of the incident light cone and of a somewhat larger image deterioration due to the larger image plane inclinations. Because of the polarization effects caused by the tilted tertiary and beamcombiner mirrors, the MMT as it is now is not suitable for polarimetry, nor can it be used well for interferometry using other than opposite mirror pairs.

The MMT presents in many ways a major departure from traditional telescope technology. This departure, risky as it may have appeared, has resulted in a relatively low cost facility and a new technology which will undoubtedly change the ways telescopes of the future will be built. The most significant departures from conventional optical telescope technology are (a) the use of light-weight "egg crate" mirrors which resulted in substantial weight savings of the telescope, (b) the use of an alt-azimuth mount which simplifies the gravitational effects on the structure, thus again resulting in a greater economy. Alt-azimuth mounts have, of course, been used elsewhere, like in the USSR