



MULTIPLE MIRROR TELESCOPE OBSERVATORY

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MMT UPGRADE/CONVERSION TECHNICAL MEMORANDUM #88-1

Subject: An $f/9$ Optical Configuration for a 6.5 M MMT Conversion.

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As part of the many design considerations towards converting the MMT to a single aperture telescope of maximum diameter, we should examine alternate optical designs. Epps presented a "first look" (MMT Technical Memorandum #18, 1986) at a configuration which derived from certain basic constraints and goals. Among others, these included:

- 1) The telescope must fit within the existing MMT building.
- 2) The focal field must be flat.
- 3) A field of at least 2 arcminute diameter must be provided at $f/45$ for IR use of the telescope.

Each of these constraints and requirements greatly effected the design. Subsequent studies (Hoffman, MMT Technical Report #22, 1987) have shown the feasibility of enlarging the MMT building, somewhat relaxing constraint 1). The use of MX type robotic fiber holders or the possibility of a curved mosaic of CCD's would relax requirement 2). Recent projections of the IR requirements of the future (Rieke '87) indicate the need for a faster IR focal ratio.

This memo presents a rough look at a possible optical configuration which is based on a different set of design goals. This design is not meant to be final; there are several areas where further research and optimization are needed. The goals chosen for this design are:

- A) Compatibility with existing MMT instrumentation.
- B) Use in the IR at a focal ratio $f/15$.
- C) A wide field at $f/9$ using refractive correctors not requiring exotic glasses.
- D) A modest field without refractive optics.

One design which meets this new set of design goals is a modified R-C with a Cassegrain focal ratio of $f/9$. This gives a reasonable field as a bare two mirror telescope and, with the addition of a single element field corrector, can cover 20 arcminutes with better than 0.14 arcsecond rms diameter images over a curved image surface.

The modification is a change in the primary and secondary conic sections away from the optimum R-C values. This sacrifices some performance in the bare telescope but enhances the performance when combined with a simple field corrector.

In this sample design, the primary focal ratio was chosen to be $f/1.2$, which is consistent with the present design for the Columbus and Magellan projects. This choice was primarily driven by use of the telescope with a chopping secondary which proved incompatible with a faster primary. A slower primary also relaxes the collimation error budget by a factor proportional to the cube of the primary focal ratio.

As an all reflecting, well collimated telescope, the usable field size is limited first by field curvature and second by field-dependent aberrations. Allowing 0.18 arcsecond rms maximum image diameter, a flat image field is limited to 5 arcminutes diameter, while a curved image surface reaches to 10 arcminutes diameter.

To increase the field size, a field corrector was added that is a single element meniscus with an asphere on the front surface. The design is similar to that of a Gascoyne type corrector plate. The chromatic aberrations of the Gascoyne plate are eliminated by bending the plate so that both surfaces are concentric about the focal plane. This makes the lens essentially achromatic. Since the glass is not used for color correction, the design can be tailored to use almost any glass which can be obtained in the 20" diameter needed.

As in the Gascoyne plate, introducing an asphere on the front surface corrects for astigmatism but introduces coma and spherical aberration. Modifying the primary and secondary conic sections partially corrects these aberrations. In addition, the asphere introduces some "secondary" color separation which is corrected by giving the meniscus a slight positive power. The final focal ratio for the corrected field is $f/8.98$ with a platescale of 3.534 arcseconds/mm. The 20 arcminute diameter field is 13.39 inches in diameter.

A quick check shows that this kind of field corrector is relatively insensitive to tilts and decenters, and works well for modest miscollimation of the secondary mirror.

The $f/15$ IR focus gives a 2 arcminute diameter field with 0.16 arcsecond rms diameter images on a curved surface. The 2 arcminute field is 2.23 inches in diameter at a platescale of 2.12 arcseconds per millimeter. The field is limited by coma which is opposite in sign to the coma induced by chopping. This leads to the phenomenon of "coma compensation" which permits a greater chop throw for a given limiting image size on the optical axis. This effect is illustrated in the attached sheets.

The attached figures show the system layout, spot diagrams for both flat and curved image surfaces for both the bare configuration and for the corrected field. The tables include the system prescription, wave aberration sums, and estimates of the system sensitivity to tilts, decenters, and defocus.