MULTIPLE MIRROR TELESCOPE OBSERVATORY

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MMTO UPGRADE/CONVERSION
TECHNICAL MEMORANDUM #88-2

Subject: Field Flattener for f/9 Optical Design

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Date: June 28, 1988

Memo 88-1 of this series presented a modified R-C telescope with f/1.2 primary and f/9 system focal ratios. One drawback of this design is the strong field curvature which arises from the fast optics. This memo presents a first cut at a simple field flattener.

Field flatteners for Cassegrain telescopes usually take the form of a negative plano-concave lens inserted just before the focal plane with the concave surface facing the secondary. The lens power is chosen to give a flat medial (best image) field. In the presence of astigmatism this occurs when the Petzval field curvature sum is opposite in sign and twice the numerical value of the astigmatism wave aberration sum.

This works well for modest field curvature. However, when the field is severely curved, the flattening lens becomes strong enough to introduce chromatic aberrations which limit the effectiveness of a single element lens. The choice of a field flattening lens is thus dependent on the desired bandpass without refocus.

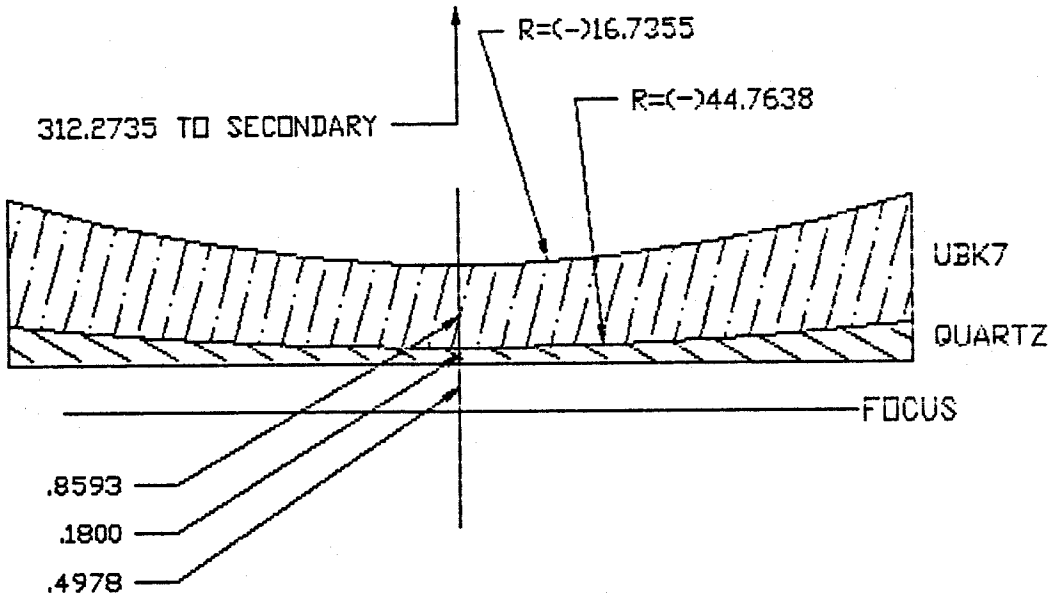
For a first attempt, a bandpass of 310 to 650 nanometers was chosen. Ironically, this is very close to the break-even point for a singlet lens. In other words, a singlet flattener designed for this bandpass gives a flat field which is equal in diameter (for a given limiting image size) to a flat cut through the field of the bare two mirror system--about 6 arcminutes with 0.2 arcsecond rms diameter images. It is clear that a field flattener for the 6.5 meter will be effective only if it is an achromat.

For an achromat, readily available glasses were chosen--UBK7 for the flint and quartz for the crown. The bandpass was extended from 310 to 1000 nanometers, and a cemented doublet configuration with spherical surfaces was chosen. Since the flattener is so close to the focal plane it is impossible to achieve both lateral and longitudinal color correction. To offset this, a lateral color aberration was introduced to overlap the red and blue images at the edge of a 12 arcminute diameter field while maintaining the desired relationship between astigmatism and Petzval wave aberrations.

The resulting lens is described in the attached sheets. It provides a flat field 12 arcminutes (8.34 inches) in diameter with 0.2 arcsecond rms diameter images over a bandpass of 310 to 1000 nanometers. At these two extremes the images overlap, but the intervening colors depart from the overlapped red and blue images--an aberration called secondary color--which could be corrected with a triplet lens, possibly extending the field. The system focal ratio is slower due to the flattener's negative power; the final focal ratio is f/9.33 for a platescale of 3.40 arcseconds per mm.

Besides secondary color, the dominant aberration in the field is distortion. The 50 microns of distortion is sufficient to displace an image at the edge of the 12 arcminute about 3/4 arcseconds towards the center of the field.

This is not meant to be a final design, only an indication of what may be achieved by adding a simple field flattener to the bare Cassegrain telescope.

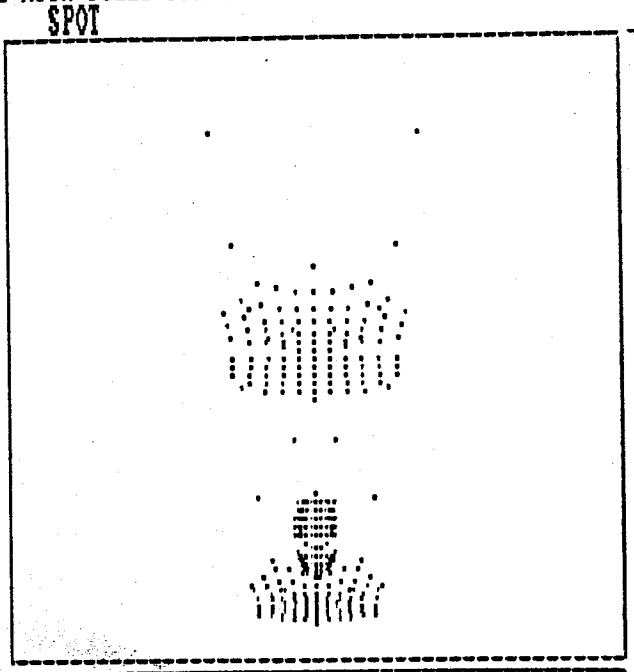


DOUBLET FIELD FLATTENER FOR MMT CONVERSION/UPGRADE

SPOT

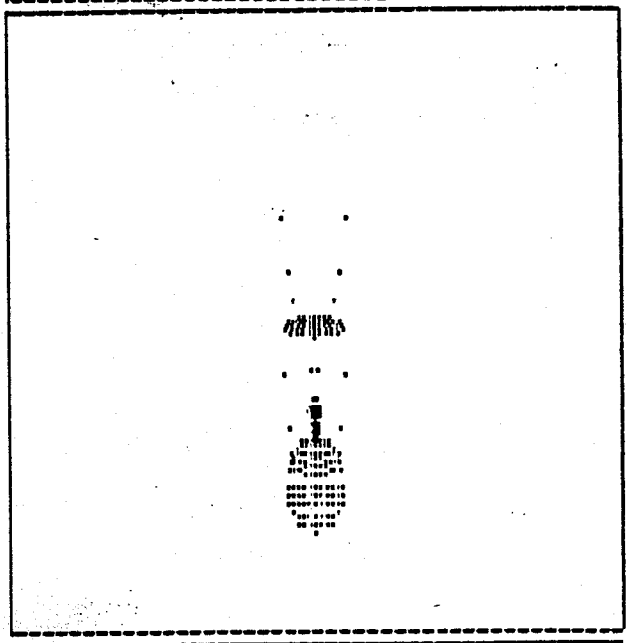
FIELD ANG .1
HALF SIZE = .002893
X= 0
Y= 4.207494
LAMBDA = 1000
LAMBDA = 500
LAMBDA = 310

RMS DIA = 2.242414E-03
= .208 "



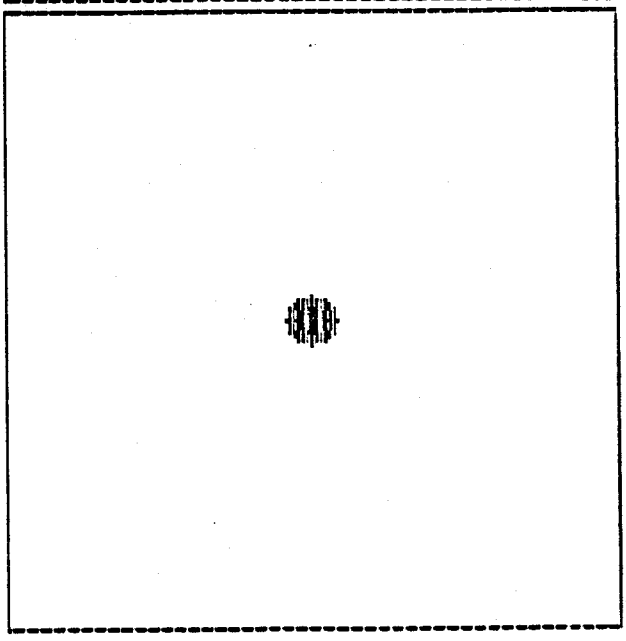
FIELD ANG .05
HALF SIZE = .002893
X= 0
Y= 2.087765
LAMBDA = 1000
LAMBDA = 500
LAMBDA = 310

RMS DIA = 1.281113E-03
= .110 "



FIELD ANG 0
HALF SIZE = .002893
X= 0
Y= 0
LAMBDA = 1000
LAMBDA = 500
LAMBDA = 310

RMS DIA = 2.462621E-04
= .021 "



MMT UPGRADE WITH FIELD FLATTENER

SURF	RAD.	THICK	N1	N2	N3		GLASS
0	******	1E+12	1.00000	1.00000	1.00000		AIR
1	-614.4001	-265.4116	-1.00000	-1.00000	-1.00000	S*	REF
2	-96.43443	312.2735	1.00000	1.00000	1.00000	*	REF
3	-16.73554	.8593318	1.50793	1.51852	1.54994		BK7
4	-44.76382	.18	1.45069	1.44323	1.25296		QUARTZ
5	******	.49784/	1.00000	1.00000	1.00000		AIR
6	******	0	1.00000	1.00000	1.00000		IMAGE

(DIMENSION IN INCHES)

ASPHERIC COEFFICIENTS

SURF= 1	C =-1.627604E-03	K =-1.0063	A4 = 0
	A6= 0	A8= 0	A10= 0
SURF= 2	C =-1.036974E-02	K =-1.781205	A4 = 0
	A6= 0	A8= 0	A10= 0

MMT UPGRADE WITH FIELD FLATTENER

THIRD ORDER

SURF	SPH	COMA	AST1	DIST	PETZ	LONG	LATC
1	-84.19	-447.79	1.88	0.00	-1.88	0.00	0.00
2	84.22	448.79	-0.13	-0.33	11.95	0.00	0.00
3	-0.04	-0.65	-1.24	-99.90	-11.76	-2.42	-18.60
4	0.00	0.00	0.00	0.05	0.44	6.97	0.77
5	0.01	-0.12	0.14	-0.69	0.00	-4.55	21.83
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUMS	0.00	0.24	0.65	-100.86	-1.24	0.00	4.00

12° FIELD ; UNITS ARE WAVES AT 500 nm