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A SCHMIDT-CASSEGRAIN CAMERA FOR USE WITH AN IMAGE INTENSIFIER TUBE

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SUMARIO

El diseño de una cámara óptica para acoplar la salida de un Espectrógrafo Cassegrain a un Intensificador de Imágenes, dio como resultado el trabajo que abajo describimos. En él se emplea básicamente un sistema Schmidt-Cassegrain concéntrico, con una lente aplanadora de campo.

ABSTRACT

The present work describes the design of an optical camera, which couples the output of a Cassegrain Spectrograph to the input of an Image Intensifier tube. The basic optical design consists of a concentric Schmidt-Cassegrain system with a small field flattener lens.

I. *Introduction*

A WL-30677 Image Intensifier tube was recently acquired by the Instituto de Astronomía of the University of Mexico to be used with the Cassegrain Spectrograph at the telescope of 1 meter aperture. The coupling of both instruments was to be done by means of an optical system of the type described by Morton (1964).

Taking into account the characteristics of the chosen Image Intensifier tube and the purpose for which the complete set up was to be used, it was agreed upon that the camera design should fulfill as closely as possible the following requisites:

Spectral Range	:	4000 Å - 9000 Å
Field Size	:	7° (2.8 cm)
Focal Ratio	:	2.8
Aperture	:	8.0 cm
Resolving Power	:	7 μm

Several possible designs satisfying these requirements were studied. The final choice was a catadioptric reflecting system with similar characteristics to those designed, for a different purpose, by Gabor (1964) and Gregory (1957).

II. *Optical Design*

The chosen system was a combination of the well known Cassegrain and Schmidt systems. The combination was formed with spherical mirrors in a concentric configuration, and a Schmidt

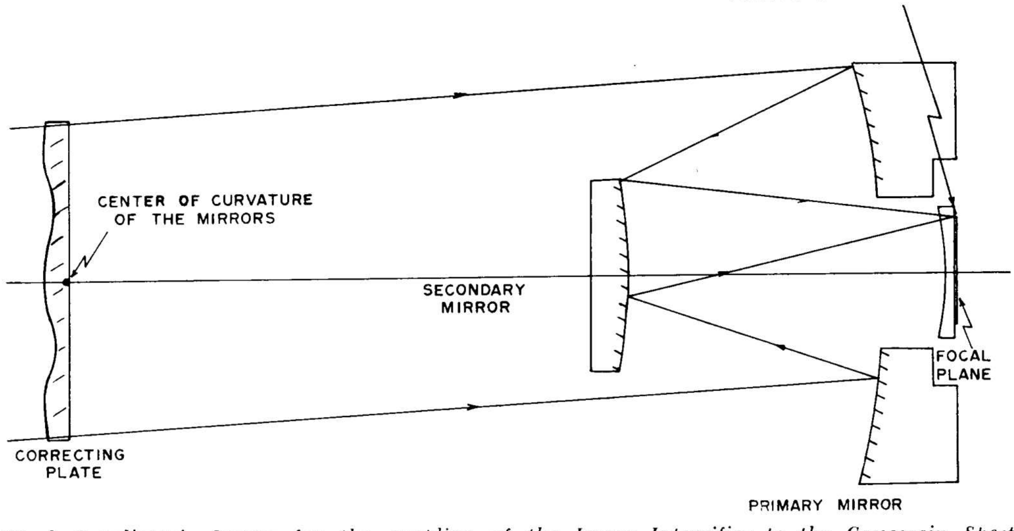

Fig. 1.—*Final Catadioptric System for the coupling of the Image Intensifier to the Cassegrain Spectrograph.*

correcting plate was used to correct the spherical aberration without contributing appreciably to increase the off-axis aberrations. The correcting plate was designed in such a way that not only the spherical aberration but also the chromatic aberration introduced was kept at a minimum value (Hilbert, 1964). Thus the only remaining problem was the field curvature; and, in order to eliminate it a small flattener lens had to be used. The final design based on these ideas is shown here.

In Figure 1 it can be noticed that both mirrors are concentric and their common center lies inside the correcting plate, near the flat face. The flattener lens is at the end of the system and inside the hole made on the primary mirror. It is important to remark that the central obscuration in this system is not small; it is, however, smaller than in all other similar designs reported in the literature.

TABLE 1

Final Parameters of the Lens Design

Radius of Curvature in cm	*Thickness in cm*	*Glass*
425.00*		
	0.7	Fused Quartz (Homosil)
∞		
	21.36	Air
−21.515		
	6.65	Air
−14.861		
	8.35	Air
− 8.5		
	0.2	Fused Quartz (Homosil)
∞		
		Air

* The aspherics constants of this surface are: $A_2 = -3.5 \times 10^{-5}$, $A_3 = 6.9 \times 10^{-7}$, $A_4 = -4.14 \times 10^{-8}$, and $A_5 = 7.8 \times 10^{-10}$.

TABLE 2

Final Characteristics of the Lens Design

Clear Aperture	8.4 cm
Focal Length	23.69 ,,
Back Focal Length	0.07 ,,
Primary Mirror Clear Diameter	11.20 ,,
Secondary Mirror Clear Diameter	5.10 ,,
Primary Mirror Central Hole Diameter	4.00 ,,
Primary Mirror Central Thickness	2.00 ,,
Secondary Mirror Central Thickness	1.2 ,,
Field Flattener Diameter	3.6 ,,
Field Diameter	7°14′
Percentage of Light Obstructed on Axis by the Secondary Mirror	38%
Focal Ratio	2.82

Use has been made of a small computer program which is being developed at the Institute of Astronomy for a wider scope of application. With that program the parameters shown in Tables 1 and 2 were obtained. Fused Quartz (Homosil) was selected for the flattener lens and Schmidt plate because of its good transparency in the desired spectral range.

The glass for the correcting plate and field flattener being chosen and the parameters of the mirrors completely determined, the computer program for optical design was used to study the complete system and find out the aspheric constants for the Schmidt plate. Such a computer program is in progress toward semi-automatization.

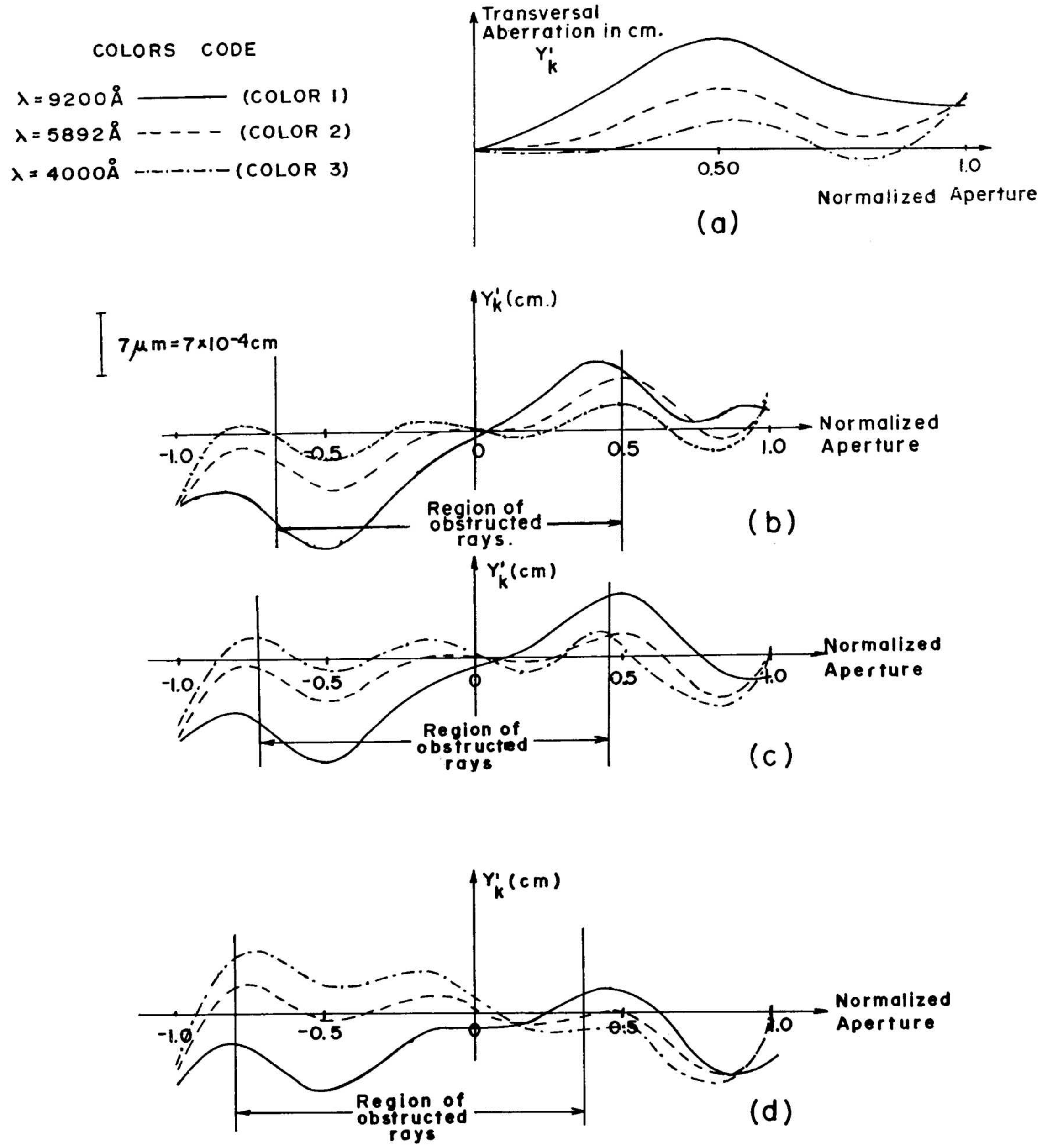

Fig. 2.—*a) Axial Aberrations for three colors; b) Meridional Transversal Aberration curves for three colors and at 0.5 cm image height (1°13'); c) at 1.0 cm image height (2°25'), d) at 1.5 cm image height (3°37').*

The final performance of the system is shown through the oblique ray graphs and spot diagram given in Figures 2, 3 and 4. Figure 2 shows the plots for axial and meridional rays (off-axis image), for three different colors and three values of the image height (0.5 cm, 1.0 cm and 1.5 cm) corresponding to 1°13', 2°25' and 3°37', respectivly.

Figures 3 (a), 3 (b) and 3 (c) show the sagittal curves for the same three colors and values of the image height. The spot diagrams in Figures 4 (a), 4 (b) and 4 (c) correspond to the same three values of the image height and the same three colors. In the different plots shown there, it can be seen that the aberrations are within an acceptable value as imposed by the desired resolving power.

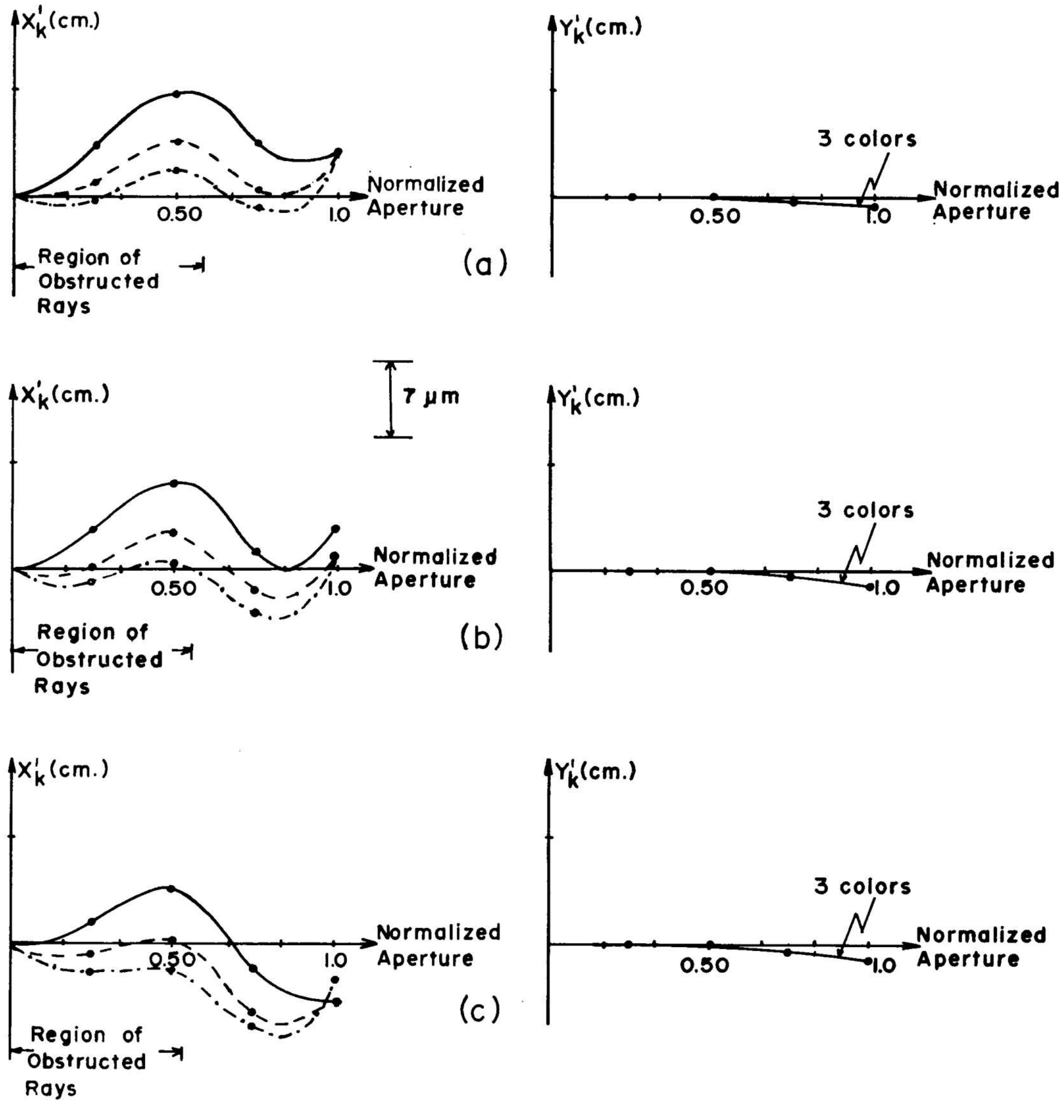

Fig. 3.—*Sagittal Transversal Aberration for three colors a) at 0.5 cm image height (1°13'); b) at 1.0 cm image height (2°25'); c) at 1.5 cm image height (3°37').*

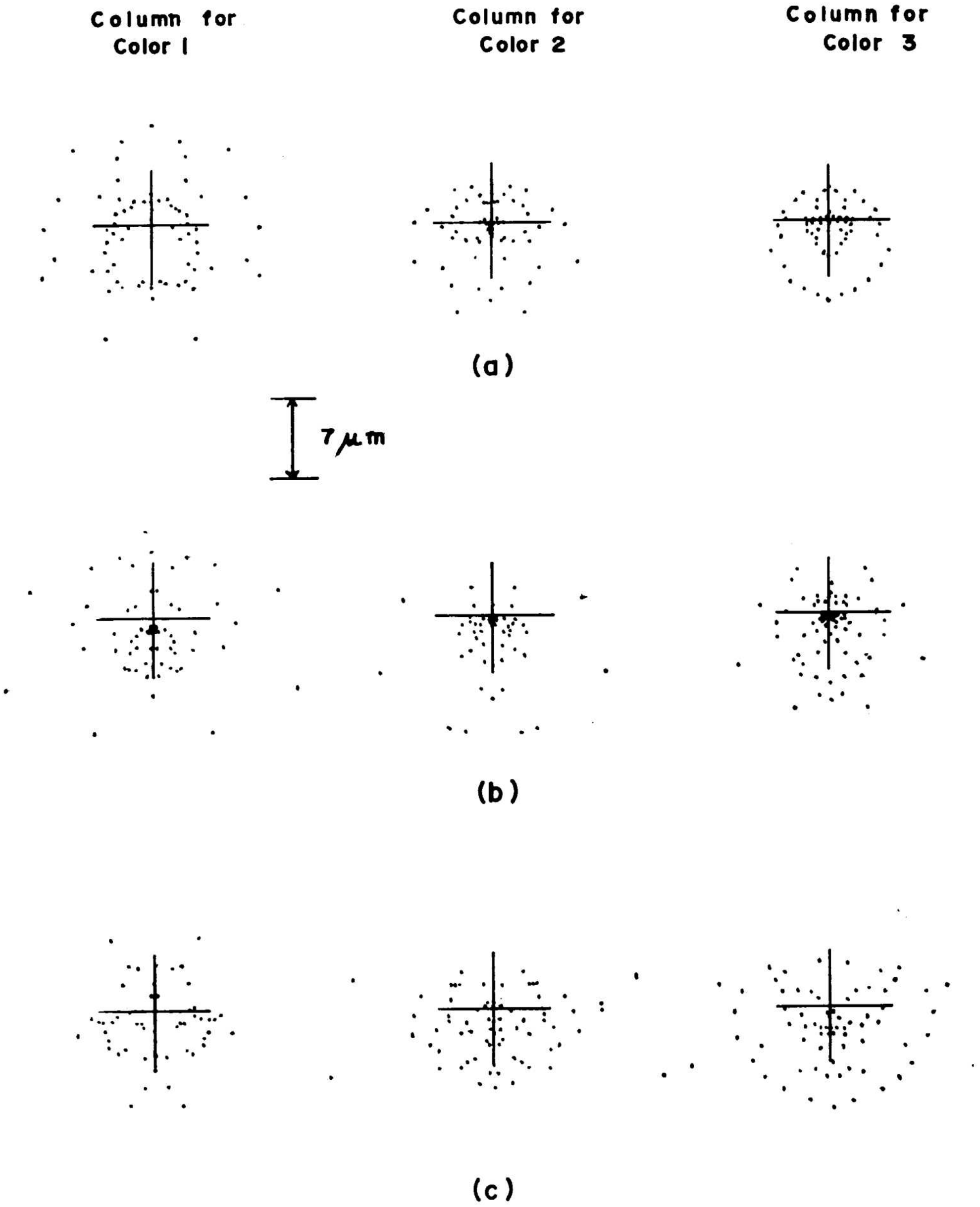

Fig. 4.—*Spot Diagrams with obstructions for three colors: a) at 0.5 cm image height (1°13′); b) at 1.0 cm image height (2°25′), c) at 1.5 cm image height (3°37′).*

III. *Conclusions*

The present design is a very compact one and is of relatively easy manufacture. Another advantage of this design is that the central obscuration, although large (38%), is smaller than that in commonly used systems.

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