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A FOLDED SCHMIDT CAMERA FOR A TELEVISION MULTICHANNEL SENSOR

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RESUMEN

Se propone el diseño óptico de una cámara Schmidt doblada f/2.9 para el acoplamiento entre un espectrógrafo Cassegrain de baja dispersión y un detector televisivo. La calidad de la imagen resulta mejor que el poder resolutivo del detector en el rango espectral comprendido entre 3000 Å y 11000 Å. La pérdida de luz debida a la obstrucción central es del orden del 15% y la inclinación del plano focal es despreciable.

ABSTRACT

An optical design of a folded Schmidt camera f/2.9, for coupling a low dispersion Cassegrain spectrograph and a TV-detector, is proposed. The image obtained is better than the detector's resolution power in the spectral range between 3000 Å and 11000 Å. The central obstruction introduces a light loss of about 15% and the focal plane tilt is negligible.
Key words: OPTICAL DESIGN—SPECTROSCOPY.

I. INTRODUCTION

A design of an optical device, for coupling a vidicon TV-tube with a low dispersion Cassegrain spectrograph, is proposed. The television detector is arranged as a 500 channel array analyser with a spectral sensitivity range between 3000 Å and 11000 Å. The sensitive zone on the face plate of the TV-tube has a length of 1.25 cm, which corresponds to a resolution power of 25 μm in the direction of the light dispersion, and a maximum height of 1 cm in the direction of the slit image. The sky light and the dark current are subtracted from each channel during the signal read-out. The dark current is also reduced by working the TV-tube at dry ice temperature. The focal ratio of the spectrograph is f/15 and its focal length is 110.5 cm.

These characteristics and the seeing limitation suggested the design of a camera with a focal ratio approximately f/2.9. In this way, the resolution and the efficiency are optimized by using the spectrograph with a slit width corresponding to 2 arcseconds. The dispersion for a 400 lines/mm grating is 2.8 Å/channel in the first diffraction order.

The wide spectral range introduces severe conditions on the design, but a flat-field Schmidt camera, with refractive elements of fused quartz (homosil) gives a good solution to this problem. Finally, a folded Schmidt camera, of the type described by Epps and Peters (1973) provides low light loss and good flexibility for the coupling with the TV-tube cooling device.

II. OPTICAL DESIGN

It is necessary to consider with care the input and output conditions that are imposed on the camera by the whole system. The input to the camera is defined by the pupil coming out from the spectro-

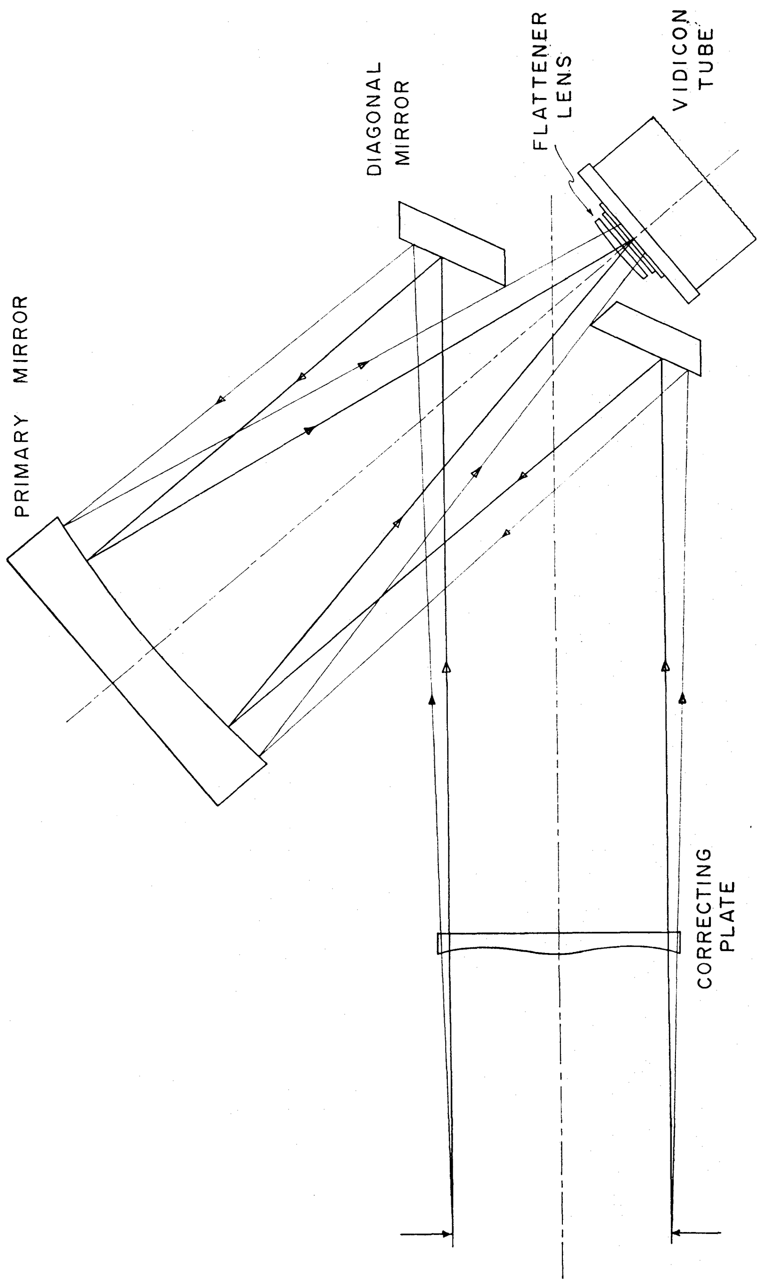

FIG. 1. Section drawing of the folded Schmidt camera f/2.9. The light dispersion is in the figure plane. Axial and marginal rays are shown.

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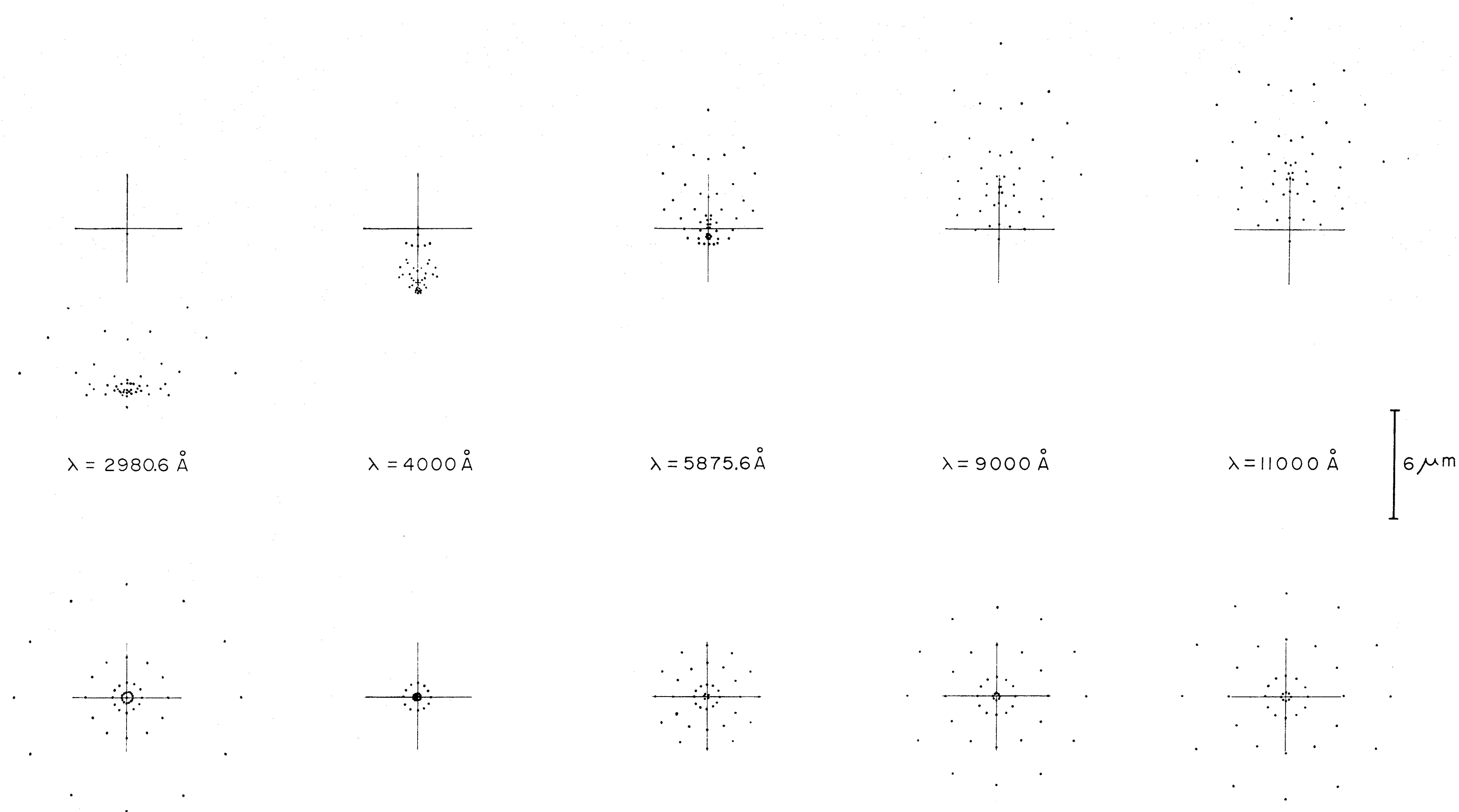

FIG. 2. Spot diagram at different wavelengths for on-axis (below) and edge images (above). Focusing is optimized

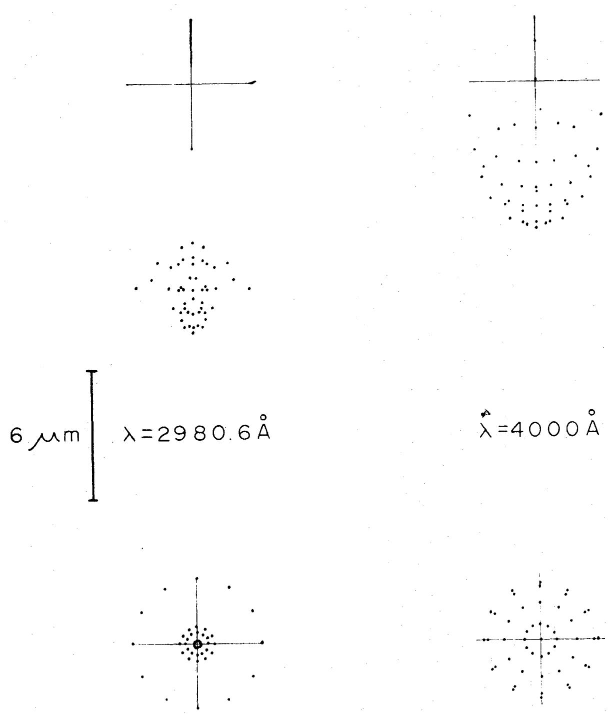

FIG. 3. Spot diagrams similar to Figure 2. Focus is optimized for ultraviolet light.

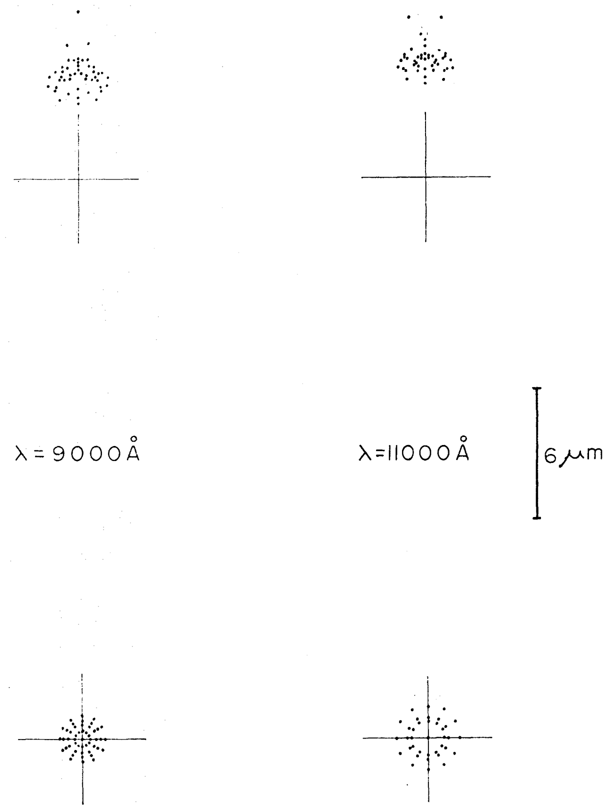

FIG. 4. Spot diagrams similar to Figure 2. Focus is optimized for infrared light.

graph grating. The distance between this pupil and the corrector plate was reduced, as far as mechanically possible, to minimize the optical aberrations. The camera output is conditioned by the TV-tube input feature: the vidicon has a quartz front face of 1.60 mm thickness and behind it is placed the silicon target at 1.23 mm; upon this target the image has to be focused. These factors have been considered in the optical design.

The camera optical features are presented in Tables 1 and 2 and the drawing of the camera is shown in Figure 1.

The central "obstruction", which is produced by the hole in the diagonal mirror, introduces a light loss of approximately 15%. The distance between the diagonal mirror and the TV-tube has been made as large as possible to obtain sufficient thermal isolation. The only optical element at dry ice temperature being the flattener field lens.

The on-axis image quality as well as the image quality at the edge of the field are shown in the spot diagrams of Figure 2 for different wavelengths. In these diagrams the focusing is optimized for blue light. It is evident that the image size is always smaller than 25 μm in all the spectral range considered; in this way, the resolution is limited by the TV-tube itself. The optical distortion is also maintained smaller than 25 μm. However, it is customary to work with limited portions of this spectral range (of the order of 1000 Å at a time). In this case,

TABLE 1

FINAL PARAMETERS OF THE LENS DESIGN

Radius of Curvature in cm	Thickness in cm	Glass
∞ *		
	9.525	Air
3124.57 **		
	0.7	Fused Quartz (Homosil)
∞		
	39.18	Air
−44.1876		
	−21.4644	Air
−9.8166		
	−0.28	Fused Quartz (Homosil)
31.9644		
	−0.11698	Air
∞ ***		
	−0.16002	Fused Quartz (Homosil)
∞		
		Air

* Pupil of the optical system.
** The aspheric constants of this surface are: $A_2 = -5.81 \times 10^{-6}$ and $A_3 = -1.29 \times 10^{-8}$.
*** Quartz plate of the vidicon TV-tube.

the camera can be focused at the desired color, thus it is possible to improve the image size, as shown in Figures 3 and 4.

As a final remark, it is interesting to note that the good image quality for a focus position, Figure 2, implies that the focal plane tilt is negligible. This makes the alignement of the TV-tube unnecessary with respect to the camera, each time that the observed spectral range is changed.

TABLE 2

FINAL CHARACTERISTICS OF THE LENS DESIGN

Design Characteristic	Final value
Clear Aperture	7.4 cm
Focal Length	21.48 cm
Back Focal Length	0.123 cm
Correcting Plate Diameter	8.20 cm
Primary Mirror Clear Diameter	11.28 cm
Flattener Lens Clear Diameter	1.99 cm
Diagonal Mirror Thickness	1.10 cm
Focal Ratio	2.90
Field Size	1.25 cm (3.33°)

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