ON THE DIFFRACTION-FIGURES DUE TO AN ELLIPTIC APERTURE.

BY C. V. RAMAN.

SYNOPSIS. Photographs are shown of the diffraction pattern obtained near the focus of a converging pencil of rays from an elliptic aperture. The transiton from the Fresnel to the Fraunhofer class of diffraction figure is traced and attention drawn to the geometric law to which the pattern conforms, namely, that the brightest part of the diffraction pattern outside the elliptic cross-section of the beam lies within the geometric evolute of this cross-section and is bounded by it.

IT is well known that the diffraction pattern at the focus of a convergent pencil of rays limited by an elliptic aperture is made up of a central spot of light surrounded by alternate dark and bright rings which are all elliptical in shape, the direction of the major axis of the rings being the same as that of the minor axis of the aperture and *vice versa*.[1] The distribution of luminosity in the focal plane may be readily deduced from the known results for the case of the circular aperture by a simple transformation of coördinates. The theory of the phenomena observed in *ultra-focal* planes is, however, considerably more complicated, and so far as the present writer is aware, has never been fully worked out for the case of elliptic apertures. Recently, while working in collaboration with Mr. R. S. Deoras, the writer made some observations on the diffraction of light by elliptic apertures for convergent and also for divergent pencils, and has noticed that the configuration of the fringes presents some rather striking geometrical features, particularly in the cases in which the eccentricity of the elliptic aperture is considerable. It is thought that a brief account of the observations, and the reproductions of some of the photographs of the diffraction-figures secured in the course of the work (Figs. 2 to 11) may be of interest to the readers of the PHYSICAL REVIEW.

Figs. 2 to 9 represent the gradual transition from the Fresnel to the Fraunhofer class as the focus of the convergent pencil is approached. In all these cases, the aperture limiting the pencil was of considerable eccentricity and had its major axis vertical. The interesting feature to which the writer wishes to draw attention is the following simple geometrical law to which the diffraction-pattern is found to conform. In

[1] Airy's Tract on the Undulatory Theory of Optics, Section 86.

Fig. 1 the heavy lines represent the elliptic cross-section of the geometric pencil of rays by the plane of observation, and also the geometric evolute of this cross-section. [The ratio of the major to the minor axis of the ellipse is taken to be greater than $\sqrt{2}$, so that two of the cusps of the evolute lie outside the cross-section.] Observation shows that the brightest part of the diffraction-pattern outside the elliptic cross-section lies within the evolute and is, in fact, bounded by it. The complete figure of the evolute may be observed visually or even photographed with sufficiently long exposures. Beyond the two cusps of the evolute, a horizontal brush or extension may also be seen on each side, as shown in Fig. 1. The evolute boundary is clearly seen in Figs. 3, 4 and 6, though in all these cases, the size of the photographic plate and the exposure were insufficient to record the whole of it.

Obviously, as the plane of observation approaches the focus of the convergent pencil, the cross-section of the pencil and the evolute both contract and ultimately reduce to a point. The horizontal brushes extending from the two cusps of the evolute, however, persist (vide Figs. 7 and 8) and break up into beads on both sides which, when the focal plane is further approached, ultimately join up and form the elliptic rings observed in the Fraunhofer pattern. Altogether, the case presents unusually interesting features in the transition from the Fresnel to the Fraunhofer class of diffraction-figure.

Fig. 10 represents the elliptic rings at the focus, for the case in which the eccentricity is small. Fig. 11 represents the rings observed in the focal plane when a *circular* reflecting surface held very obliquely forms the diffracting aperture. Some degree of asymmetry is observable in this figure.

The writer hopes to be able to present a fuller study and mathematical treatment in due course.

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PLATE I.
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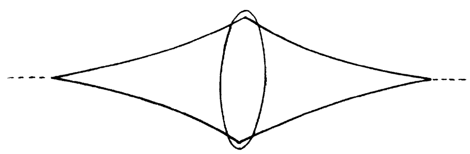

FIG. 1.

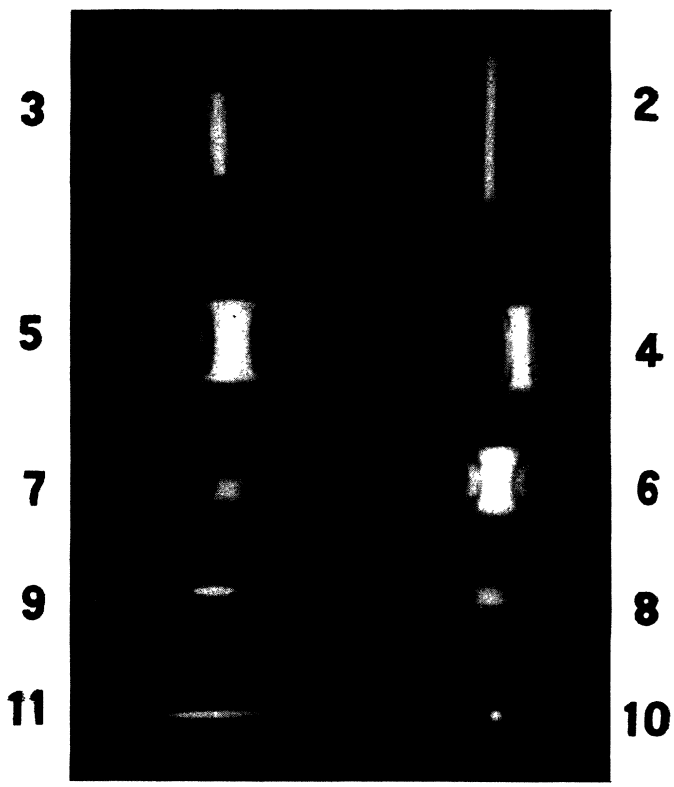

FIG. 2.

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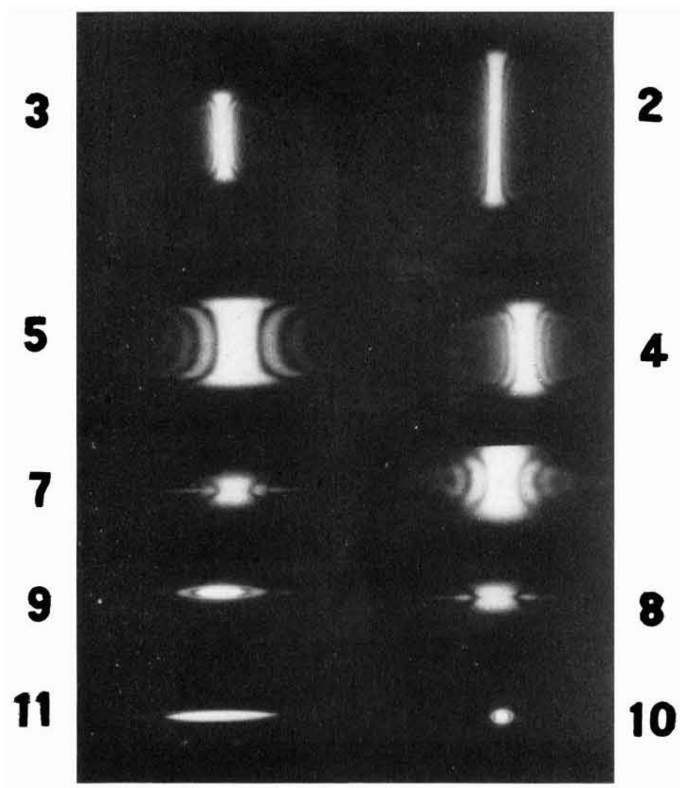

Fig. 2.