SEM-II
Hons (C IV: WAVES AND OPTICS)
L-8
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Fresnel diffraction pattern of a straight edge:

AB is an opaque obstacle in the form of a knife edge at a distance a from the source S. Both the slit S and the edge A of AB are parallel and normal to the plane of the paper. Let the wavelength of light emitted from S be $\lambda . POQ$ is a screen beyond the obstacle at a distance b from AB. Due to the slit S cylindrical wave front will be obstructed by the straight edge AB. We will get the diffraction pattern on POQ from the wavelets arising from the wave front CA only.

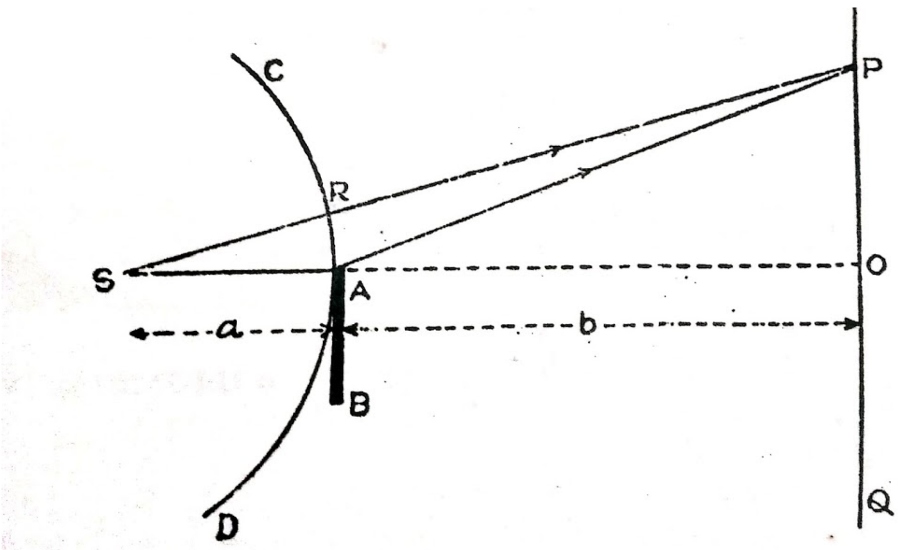

Figure 1: Diffraction at straight edge

The nature of the diffraction fringes will be as follows:

1. Above the line AO, there will be alternate bands of light and

dark fringe of unequal width. As we proceed more and more away from O the bands will become closer till they vanish leading to a general illumination.

2. Below the geometrical shadow the illumination below AO vanish gradually but rapidly.

Let us consider a point P on the screen. The straight line SP meets the wavefront CA at R. So R is the pole of the wave front with respect to the point P. The effect P may be regarded as the sum of the effects of the unobstructed half wave lying above R and the portion of the wave front RA. The former effect is constant for all points lying above O on the screen and hence the effect at any of these points depends on whether a number of Fresnel half period zones contained in RA is odd or even. If the number is odd the effect is maximum , if even a minimum. The final result therefore the geometrical shadow at O is flanked with a series of alternatively bright and dark diffraction bands.

To determine whether any point P corresponding to maximum or minimum we commence by noting the number of zones in the wave front is equal to the number of half wavelength in the difference $(AP-RP)$. From the geometry , if we represent OP by y then

$$SP = \{(a+b)^2 + y^2\}^{\frac{1}{2}}$$
$$= (a+b)\{1 + \tfrac{y^2}{(a+b)^2}\}^{\frac{1}{2}}$$
$$\text{Therefore } SP = (a+b) + \tfrac{1}{2}\tfrac{y^2}{(a+b)}$$
$$\text{or } RP = SP - a = b + \tfrac{1}{2}\tfrac{y^2}{(a+b)}$$
$$\text{Similarly } AP = (b^2 + y^2)^{\frac{1}{2}} = b + \tfrac{1}{2}\tfrac{y^2}{b}$$
$$\text{Hence } AP - RP = \tfrac{y^2 a}{2b(a+b)}$$
$$\text{For a minimum } AP - RP = n\lambda \quad n = 1, 2, 3, ...$$

$$y^2 = \frac{b(a+b)}{a} 2n\lambda \tag{1}$$

and for a maxima $AP - PR = (n + \frac{1}{2})\lambda, \quad n = 1, 2, 3, ...$

$$or \quad y^2 = \frac{b(a+b)}{a}(2n+1)\lambda \tag{2}$$

Equation (1) shows that the diffraction bands are not evenly spaced: y being proportional to$\sqrt{n}$. Inside the edge of the geometrical shadow at O we have the effects produced by the incomplete half wave front lying above A. As effect depends essentially on the first zone only and this become gradually and continuously smaller and more oblique, a gradual diminution in intensity is observed as we enter the geometrical shadow. The maximum intensity occurs at a short distance out from the edge of the geometrical shadow for the portion when RA is the radios of the first zone.

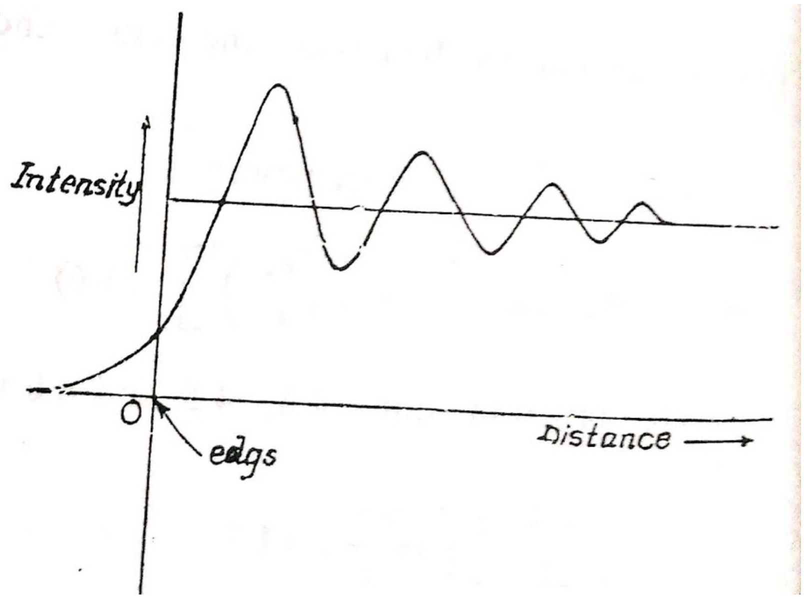

Figure 2: Intensity distribution of diffraction pattern of straight edge