* Explain Fresnel's theory of diffraction or Fresnel's half period zone theory of diffraction.

Fresnel proposed the theory of diffraction of light on the basis of half period or half wavelength zone. Starting in the simplest case with parallel beam of light source, we have a ~~[illegible]~~ plane wavefront. The effect of this plane wavefront is to be calculated at the central point P. This is shown in Fig 1.

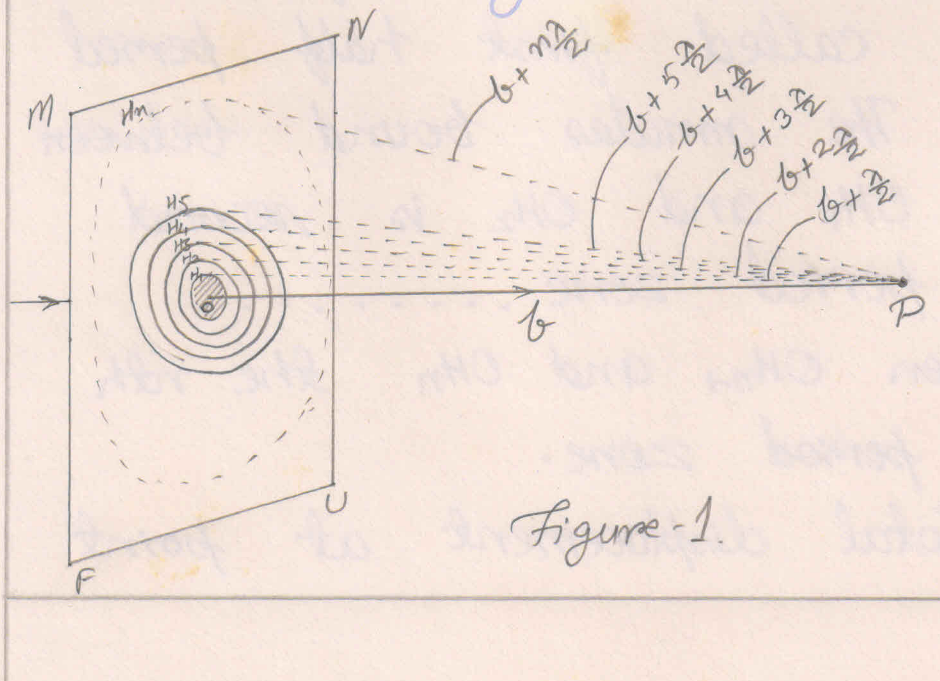

Figure-1.

As shown in Fig 1 let the section of the plane wavefront be represented by MNUF. Point P is along central line for this section with perpendicular distance $PO = b$. If we now draw a sphere of radius $PO = b$ with P as a centre then point O is the pole of P. We next draw spheres with the same centre and radii $b + \frac{\lambda}{2} = PH_1$, $b + 2\frac{\lambda}{2} = PH_2$, $b + 3\frac{\lambda}{2} = PH_3$, $b + 4\frac{\lambda}{2} = PH_4$, ...
.........., $b + n\frac{\lambda}{2} = PH_n$.

Then, the circle of radius OH_1 is called first half period zone. The annulas bound between radii OH_1 and OH_2 is second half period zone ....
between OH_{n-1} and OH_n the nth half period zone.

Total displacement at point

P is the resultant of the wavelets sent by these half-period zones.

Area of first half period zone is given by

$$A_1 = \pi \cdot OH_1^2$$
$$= \pi \left\{ \left(b+\frac{\lambda}{2}\right)^2 - b^2 \right\}$$
$$= \pi \left\{ b\lambda + \frac{\lambda^2}{4} \right\} \cdots\cdots\cdots (i)$$

The area of second half period zone is given by

$$A_2 = \pi \left\{ (OH_2)^2 - (OH_1)^2 \right\}$$
$$= \pi \left[\left\{ (b+\lambda)^2 - b^2 \right\} - \left\{ \left(b+\frac{\lambda}{2}\right)^2 - b^2 \right\} \right]$$
$$= \pi \left\{ b\lambda + \frac{3}{4}\lambda^2 \right\} \cdots\cdots (ii)$$

. . . .

. . . .

. . . .

In general the area of nth half period zone will be

$$A_n = \pi \left\{ b\lambda + (2n-1)\frac{\lambda^2}{4} \right\} \cdots\cdots (iii)$$

Thus the area of half-period zones goes on increasing with number.

If $d_1, d_2, \ldots\ldots d_n$ be the displacements of ether particles produced at P due to first, second, ... nth half period zones, then due to half wavelength difference their phases will be opposite and the resultant is given by

$$D = d_1 - d_2 + d_3 - d_4 + \ldots\ldots \pm d_n \quad \ldots\ldots (iv)$$

Where +ve for $n = (2m+1)$ i.e. odd and -ve for $n = 2m$ i.e. even and $m = 1, 2, 3, 4, \ldots$

Now we can write expression (iv) as

$$D = \frac{d_1}{2} + \left(\frac{d_1 + d_3}{2} - d_2\right) + \left(\frac{d_3 + d_5}{2} - d_4\right) + \ldots\ldots \pm \frac{d_n}{2} \quad \ldots\ldots (v)$$

In this if we take n odd then

$$D = \frac{d_1}{2} + \frac{d_n}{2} \quad \ldots\ldots\ldots\ldots (vi)$$

where other terms cancel.

In equation (vi) even for small size of wavefront MNUF n is very large, therefore

$$\frac{d_n}{2} \longrightarrow 0 \quad \text{due to obliquity}$$

Finally we are left with

$$D = \frac{d_1}{2} \quad \ldots\ldots\ldots\ldots (vii)$$

The intensity

$$I = D^2 = \frac{d_1^2}{4} \quad \ldots\ldots (viii)$$

Thus Fresnel's theory indicates that diffraction phenomenon is due to mutual interference between the wavelets sent by different parts of the same wavefront (not two wavefronts as in interference). This is why the displacement is decreased i.e; halved of even the contribution of the first half period and the intensity is one fourth (i.e; $\frac{1}{4}$).

This theory also explains approximately the rectilinear propogation of light.

If a small object is placed at the central point P of the screen relative to pole O then a shadow is formed. This explains the rectilinear propogation of light.