1.9 REFERENCES

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7.6 FRESNEL'S HALF PERIOD ZONES

According to Huygens principle each point on a wavefront acts as a source of secondary disturbance. When a wavefront is made to incident on a slit, most of it is obstructed by the slit. The small portion of the wavefront passed through the slit is, thus, equivalent to a string of coherent point sources. The intensity at any point on the screen may be obtained by suitably summing the intensities of wavelets originating from those point sources at the slit and superposing at that point of screen. Thus diffraction pattern is formed at screen due to the interference of secondary wavelets.

Since the coherent sources are located at different distances from any point on the screen, the waves reach that point with differing phases. Their superposition produces interference pattern with maxima and minima formation. Therefore, the diffraction of light is due to the superposition of waves from coherent sources of the same wavefront after the wavefront is obstructed by obstacle or aperture.

7.6.1. Construction of Zones

For the qualitative understanding of the diffraction pattern, Fresnel introduced the idea of half period zones. The wave-front originated from the source and striking the obstacle or aperture is divided into a number of the circular and the concentric zones. Zone is the small area on the plane wave-front with reference to the point of the observation such that all the waves from the area reach the point without any path difference. The paths of light rays from the successive zones differ by $\lambda/2$. Since path difference of $\lambda/2$ corresponds to half time period, these zones are known as half period zones.

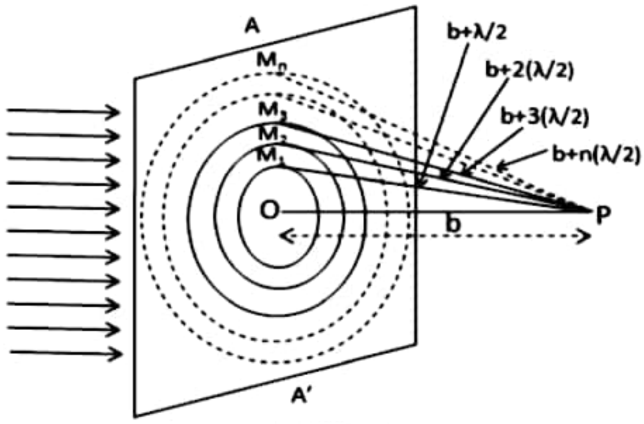

Figure 7.7

In order to understand the construction of half period zones taking a plane wavefront AA' and droping a perpendicular PO on the wavefront from an external point P. If the distance PO is b then taking P as a centre draw spheres of radii $b+\lambda/2$, $b+2(\lambda/2)$, $b+3(\lambda/2)$ *etc.* The spheres will cut the wavefront AA' in circles of radii OM_1, OM_2, OM_3 etc as shown in figure 7.7. The annular regions between two consecutive circles are called ***half period zones***, e.g., the annular region between $(n-1)^{th}$ circle and n^{th} circle is called the n^{th} half period zone.

7.6.2. Radii and Area of Zones

From simple geometry the radius of n^{th} such circle, OM_n, can be written as

$$OM_n = r_n = \left[\left(b + n\frac{\lambda}{2}\right)^2 - (b^2)\right]^{1/2}$$

$$= \sqrt{n\lambda b}\left[1 + \frac{n\lambda}{4b}\right]^{1/2} = \sqrt{n\lambda b} \qquad \text{.......} \quad (7.1)$$

Here we have assumed $b >> \lambda$, which is true in most of the experiments using visible light. We have also assumed here that n is not a very large number. From expression given by equation (7.1), it is clear that the radii of half period zones are proportional to the square roots of natural numbers. Therefore, the radii of first, second, third etc. half period zones are $\sqrt{\lambda b}$, $\sqrt{2\lambda b}$, $\sqrt{3\lambda b}$ etc

With the help of equation (7.1), the area of n^{th} half period zone is given by

$$A_n = \pi r_n^2 - \pi r_{n-1}^2 = \pi[n\lambda b - (n-1)\lambda b] = \pi\lambda b \qquad \text{....... (7.2)}$$

Thus for $b >> \lambda$ and n not very large, the areas of half period zones are independent of n and are approximately equal for fixed value of λ and b. The area of the zone may be varied by varying the wavelength of light used and the distance of the point from the wavefront.

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