Answer on Question #50693, Physics, Optics

a) Discuss Rayleigh's criterion for resolving power of an optical instrument. Obtain an expression for the resolving power of a microscope.

b) A He-Ne laser emits a beam of diameter 2×10^{-3}m and wavelength 630 nm. It is directed towards an aeroplane flying at a height of 11 km. Calculate the diameter of the light patch produced on the surface of the aeroplane.

Answer:

a) By resolving power of an optical instrument we mean its ability to produce separate images of objects very close together. Using the laws of geometrical optics, one designs a microscope or a telescope. However in the final analysis it is the diffraction pattern which sets a limit on the resolving power. For example, consider two nearby sources. Only when the diffraction patterns of these two sources are separate will they appear separate. When the central maxima fuse, the two sources appear as one. When the central maximum of one source coincides with the first minimum of the other, the resolution is marginal, a condition called Reyleigh`s criterion (Fig.1)

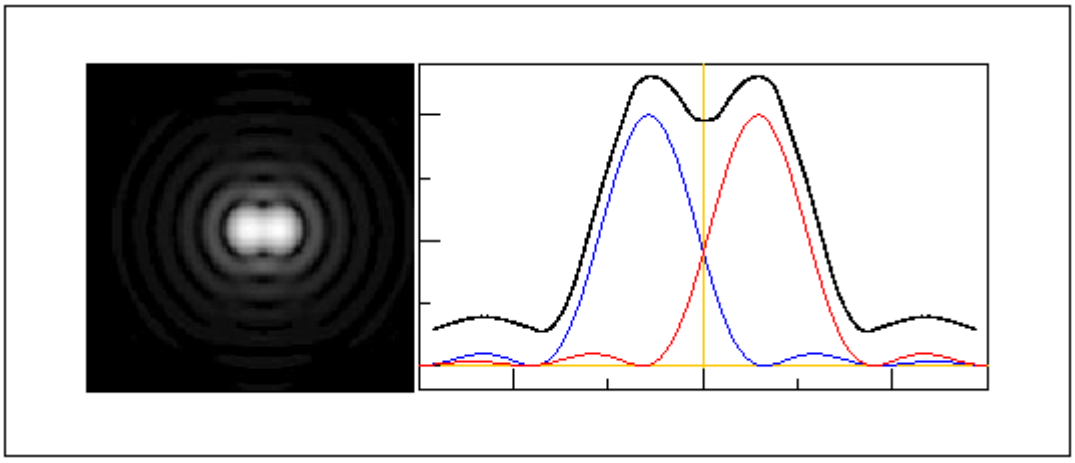

Fig.1

The minimum angle is

$$\theta_{\min} = 1.22\frac{\lambda}{D} \qquad (1)$$

where D is a lens of diameter, λ is a wavelength.

In the case of a microscope the object is held very close to the objective and the object subtends an angle say 2α as shown in Fig. 2. So in this case $d = \frac{1.22\lambda}{2\sin\alpha}$.

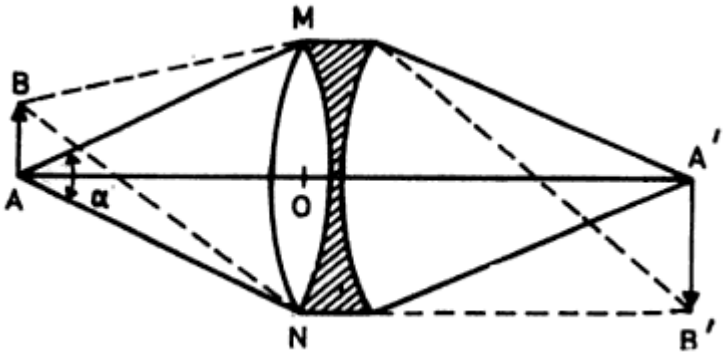

Fig.2

b)

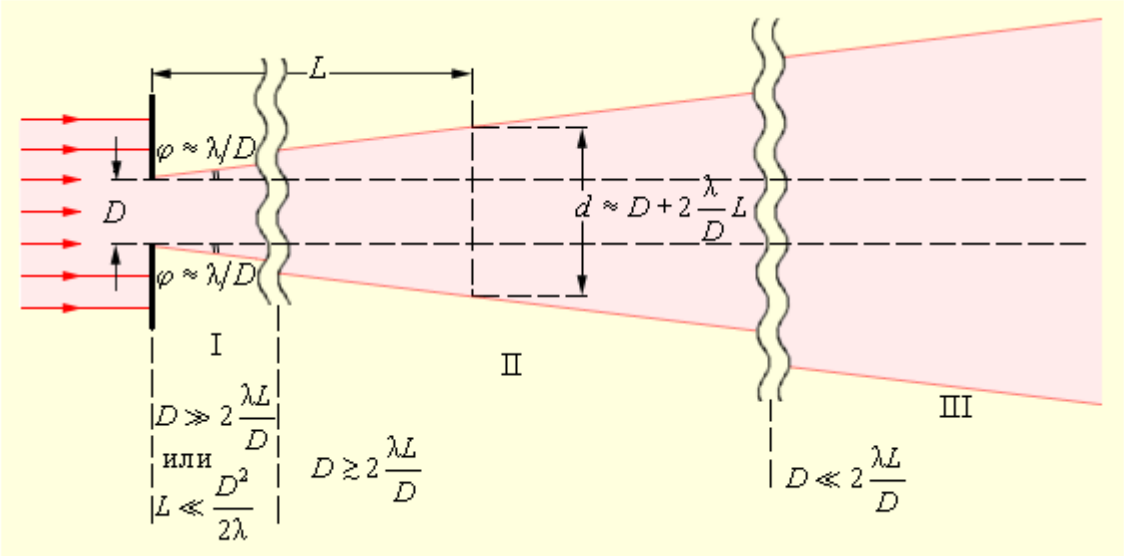

Fig.1

The diameter of the light patch produced on the surface of the aeroplane (see Fig.1).

$$d = D + 2\frac{\lambda}{D}L = 2\cdot 10^{-3} + 2\cdot\frac{630\cdot 10^{-9}}{2\cdot 10^{-3}}\cdot 11\cdot 10^{3} = 6.93m$$