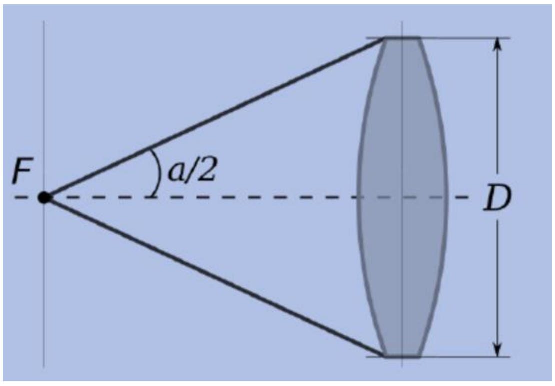
Answer on Question #61924-Physics-Optics

'Diffraction limits the image forming capability of optical devices'. Discuss the authenticity of this statement for the particular case of a microscope

Solution

Microscope resolution is the shortest distance between two separate points in a microscope's field of view that can still be distinguished as distinct entities. The phenomenon of diffraction explains the microscope resolution (diffraction refers to various phenomena which occur when a wave encounters an obstacle or a slit). The lens of the microscope is limited in size. Therefore, there is diffraction of light at a round hole. Luminous points of the object will depicted in the form of light spots. Set of dark and light diffraction rings will form these light spots. And because the images of two pretty close luminous points can overlap. Two luminous points can still be seen separately, if the light diffraction rings overlap is not greater than the radius of the spot.



Microscope resolution:

$$\Delta l = \frac{\lambda}{2A} \ (1),$$

where λ – wavelength of light, A – numerical aperture of objective.

Numerical aperture of objective:

$$A = n \sin \alpha \ (2),$$

where n – absolute index of refraction (medium between the object and the lens of the microscope), α – angular aperture (the angle at which visible the diameter of the lens from the object point F)

Put (2) in (1):

$$\Delta l = \frac{\lambda}{2n \sin \alpha} \qquad (3)$$

If $n \approx 1$ (air) and $\sin \alpha \le 1$, then

$$n \sin \alpha \le 1 \qquad (4)$$

From (3) and (4) we have

$$\Delta l \ge \frac{\lambda}{2} \qquad (5)$$

Thus, wavelength of light determines the microscope resolution.

Limits wavelength for visible light:

$$380 \cdot 10^{-9}\, m - 760 \cdot 10^{-9}\, m \qquad (6)$$

So,

$$\Delta l \geq 200 \cdot 10^{-9}\, m$$

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