Answer on Question #53759, Physics Solid State Physics

A laser beam of wavelength $6X10^{-7}$ m , coherence width $8X10^{-3}$m and power 10mW shines on a surface 100m away. Deduce the illumination , compare it with that due to a collimated beam from a torch filament of diameter 0.1cm , lens of focal length 10cm and power 10W.

Solution

The semi angle of cone of laser beam

$$\theta = \frac{\lambda}{a} = \frac{6 \cdot 10^{-7}}{8 \cdot 10^{-3}} = 7.5 \cdot 10^{-5} rad$$

Solid angle

$$\Omega = \frac{\Delta S}{r^2} = \frac{\pi (r\theta)^2}{r^2} = \pi\theta^2$$

Areal speed

$$\Delta A = r^2\Omega = \pi\theta^2 r^2 = 3.14 \cdot \left(7.5 \cdot 10^{-5}\right)^2 \cdot (100)^2 \, m^2$$

Illumination

$$E = \frac{P}{\Delta A} = \frac{10 \cdot 10^{-2}}{1.76 \cdot 10^{-4}} = 57 W / m^2$$

For a torch, the angle subtended by the filament size at the lens,

$$\theta' = \frac{0.1cm}{10cm} = 10^{-2} rad$$

Areal speed

$$\Delta A = r^2 \Omega = \pi \left(\theta'\right)^2 r^2 = 3.14 \cdot \left(0.01\right)^2 \cdot \left(100\right)^2 = 3.14 m^2$$

Illumination

$$E = \frac{P'}{\Delta A'} = \frac{10}{3.14} = 3.2 W / m^2$$