Answer on Question #53724, Physics Solid State Physics

a laser beam of wavelength 630 nm coherence width 8x10 $^{-3}$ m and power 10mw shines on a surface 100 m away. deduce the illumination. compare it with that due to a collimated beam from a torch filament of diameter 0.1 cm , lence of focal length 10 cm and power 10 w

Solution

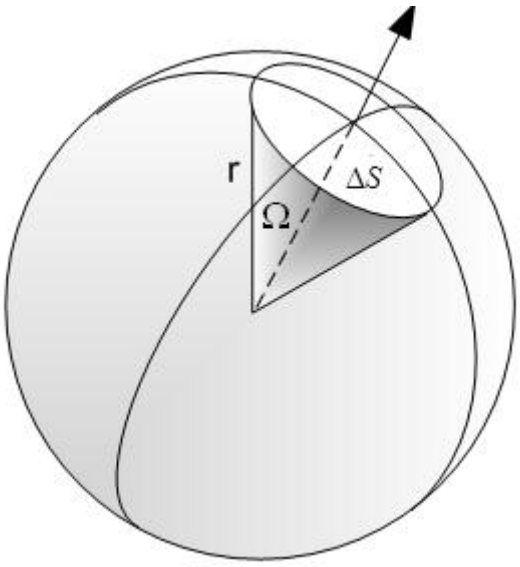

Fig.1

Solid angle (see Fig.1)

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

where $\theta = \lambda / a$ is the semi angle of cone of laser beam; λ is the wavelength of light; a is the coherence width.

Illumination

$$E = \frac{P}{\Delta S} = \frac{a^2 P}{\pi \lambda^2 r^2} = \frac{\left(8 \cdot 10^{-3}\right)^2 \cdot 10 \cdot 10^{-2}}{3.14 \cdot \left(630 \cdot 10^{-9}\right) \cdot 100} = 57 W / m^2,$$

where $\Delta S = r^2 \Omega = \pi \theta^2 r^2$ is the areal speed

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

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

So, illumination

$$E = \frac{P'}{\Delta S'} = \frac{P'}{\pi \left(\theta'\right)^2 r^2} = \frac{10}{3.14 \cdot \left(0.01\right)^2 \cdot \left(100\right)^2} = 3.2 W / m^2$$

where $\Delta S' = r^2 \Omega = \pi \left(\theta'\right)^2 r^2$.