08/21 Class Notes

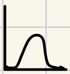
Review of Basic Lab concepts

Gaussian Beam

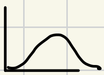
↳ light beams emitted by lasers have gaussian intensity distributions.

$$I = I_0 e^{-2r^2/w^2}$$

$\odot$ } intensity dropoff from center of pointer is different on short and long axes.



short axis dropoff



long axis dropoff

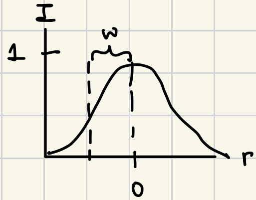
→ how do we evaluate intensity?

Amount of photons/sec

$\therefore$ energy/s/ m^2

= joules/m^2

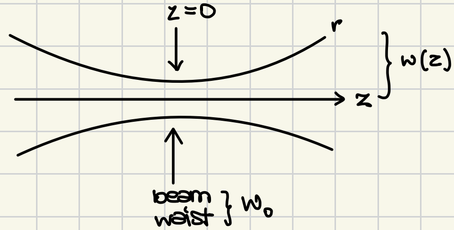
= power (watts)



→ the gaussian beam propagates through space.

Beam waist w_0 $\longrightarrow$ $w(z) = w_0\sqrt{1 + (z/z_0)^2}$

confocal parameter (Rayleigh Range): Z_0 $\longrightarrow$ $z_0 = \frac{k w_0^2}{2}$



if $z >> z_0$:

↳ $w(z) \approx w_0 \sqrt{\frac{z}{z_0}}$ (1 becomes trivial)

further from waist:

$w \approx \frac{2z}{k w_0}$ } k = wave number.

$\therefore$ divergence angle $\vartheta = 2\frac{w}{z} = \frac{4}{k w_0} = \frac{2\lambda}{\pi n w_0} \approx 0.637\frac{\lambda}{w_0}$

and $\tan\frac{\vartheta}{2} = \frac{w}{z}$

↳ $= \frac{w_0 \frac{z}{z_0}}{z} = \frac{w_0}{z} = \frac{w_0}{\frac{k w_0^2}{z}} = \frac{2}{k w_0} = \frac{2}{\frac{2\pi}{\lambda} w_0} = \frac{\lambda}{\pi w_0}$

→ what are additional components of light as a wave?

λ (wavelength) $\quad$ ω (ang. freq.)

T (period) $\quad$ k (wave number)

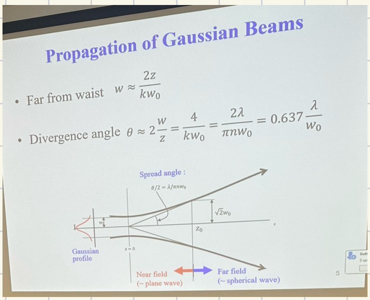
v (speed) $\quad$ f (frequency)

$C = 3E8$

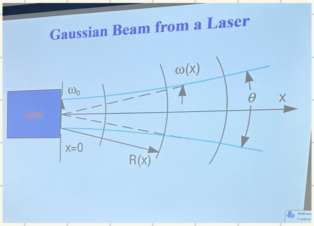
ϕ = phase

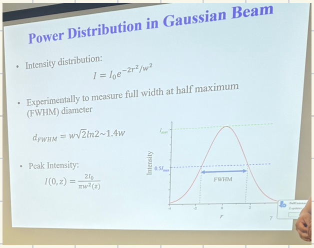
$$\left.\begin{aligned} \lambda &= \frac{c}{f} \\ f &= \frac{1}{T} \\ \omega &= 2\pi f \\ k &= \frac{2\pi}{\lambda} \end{aligned}\right.$$

$v = \lambda f = \frac{\lambda}{T}$



→ intuitively, the minimum waist of the beam will be closest to $z=0$.





→ how can we actually measure light intensity?

- photodiodes!
- sensors to measure power of light.

↳ photons incident on semiconductor junction.

→ reverse bias mode (why?)

→ photocurrent $\propto$ light intensity

might need to explain how this works in methods...

→ depending on the photodiode material, different λs may produce different responses.

- e.g. silicone ⟶ VLS (400~700nm)