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Gaussian Beam Optics

Lens Selection

The most important relationships that we will use in the process of lens selection for Gaussian beam optical systems are as follows:

Focused Spot Radius

$$w_F = \frac{\lambda f M^2}{\pi w_L}$$

where w_F is the spot radius at the focal point, and w_L is the radius of the *collimated beam* at the lens. M^2 is the quality factor (1.0 for a theoretical Gaussian beam).

Beam Propagation

$$w(z) = w_0 \left[1 + \left(\frac{\lambda z M^2}{\pi w_0^2} \right)^2 \right]^{1/2}$$

and

$$w_0(\text{optimum}) = \left(\frac{\lambda z M^2}{\pi} \right)^{1/2}$$

where w_0 is the radius of a real (non-Gaussian) beam at the waist, and $w(z)$ is the radius of the beam at a distance z from the waist. For $M^2 = 1$, the formulae reduce to that for a Gaussian beam. $w_0(\text{optimum})$ is the beam waist radius that minimizes the beam radius at distance z .

Finally,

$$z_R = \frac{\pi w_0^2}{\lambda}$$

where z_R is the Raleigh range.

We can also utilize the equation for the approximate on-axis spot size caused by spherical aberration for a plano-convex lens at the infinite conjugate:

$$\text{spot diameter (3rd-order spherical aberration)} = \frac{0.067 f}{(f/\#)^3}$$

This formula is for uniform illumination, not a Gaussian intensity profile. However, since it yields a larger value for spot size than actually occurs, its use will provide us with conservative lens choices. Keep in mind that this formula is for spot diameter whereas the Gaussian beam formulas are all stated in terms of spot radius.

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