M^2-200 / M^2 200s Beam Propagation Analyzers

What is M^2?

M^2, or Beam Propagation Ratio, is a value that indicates how close a laser is to being a single mode TEM_{00} beam. This in turn relates t how small a spot a laser can be focused.

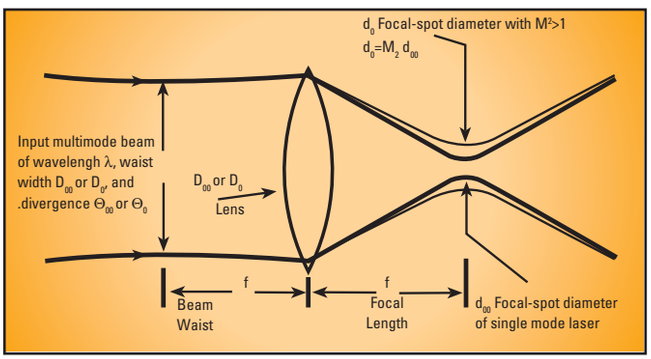
For a laser beam propagating through space, the equation for the divergence, Θ, of a pure Gaussian TEM_{00} unfocused beam is given by

$$\Theta_{00} = 4\lambda/\pi D_{00} \quad (1)$$

where D_{00} is the waist size of the beam, and λ is the wavelength. Actual beams with additional modes often start with a larger beam waist, D_0, and/or have a faster divergence Θ_0. In this case Equation (1) becomes

$$\Theta_0 = M^2 4\lambda/\pi D_0 \quad (2)$$

where Θ_0 and D_0 are the divergence and width of a higher mode beam and M^2 is greater than 1 and is named the "Beam Propagation Ratio" per the ISO 11146 standard. When a pure Gaussian laser beam is focused, the width of the focused spot is defined by:



Characteristics of a laser beam as it passes through a focusing lens.

$$d_{00} = 4\lambda/\pi D_{00} \quad (3)$$

where d_{00} is the ideal focused spot width, f is the focal length of the lens, and D_{00} is the width of the input beam waist and is placed one focal length from the lens as shown in the figure (above).

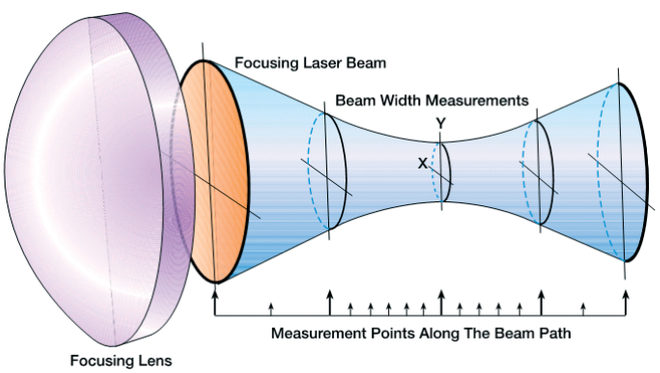
However, when a distorted or multimode beam is focused, Equation (1) becomes:

$$d_0 = M^2 4\lambda f/\pi D_0 \quad (4)$$

How is M^2 measured?

M^2 cannot be determined from a single beam profile measurement. The ISO/DIS 11146 requires that M^2 be calculated from a series of measurements as shown in the figure below. M^2 is measured on real beams by focusing the beam with a fixed position lens of known focal length, and then measuring the characteristics of the artificially created beam waist and divergence.

To provide an accurate calculation of M^2, it is essential to make more measurements in the focused beam waist region, and a number of measurements in both the far fields. The multiple measurements ensure that the minimum beam width is found. In addition, the multiple measurements enable a "curve fit" that improves the accuracy of the calculation by minimizing measurement error at any single point. An accurate calculation of M^2 is made by using the data from the multiple beam width measurements at known distances from a lens, coupled with the known characteristics of the focusing lens.



Multiple beam width measurements made by M^2-200