State-of-the-art measurement of the laser beam divergence

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Motivation

The design of optical systems that employ lasers requires precise knowledge of the laser beam propagation characteristics. These include beam waist diameter and location, Rayleigh range, beam divergence angle, and beam propagation factor.

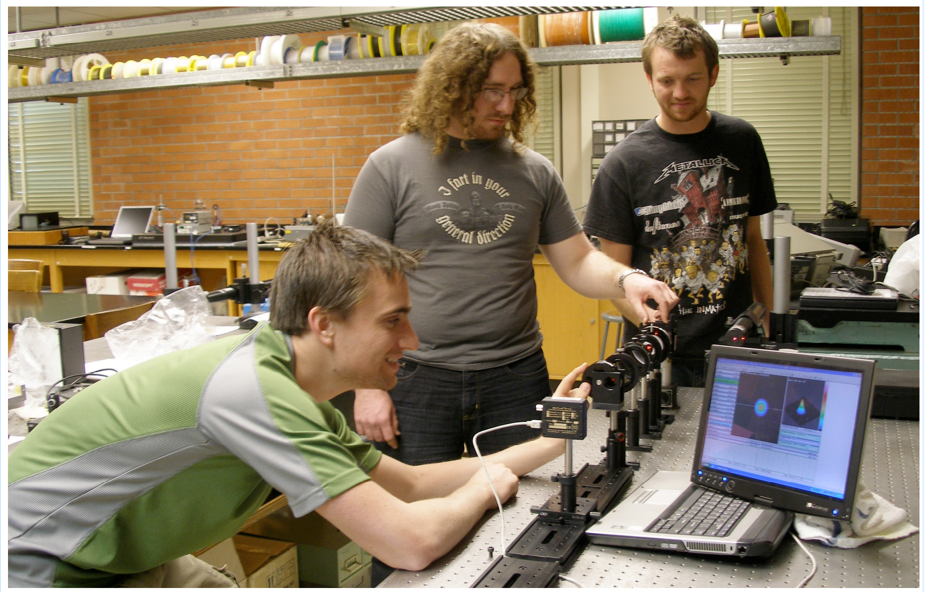
Goal

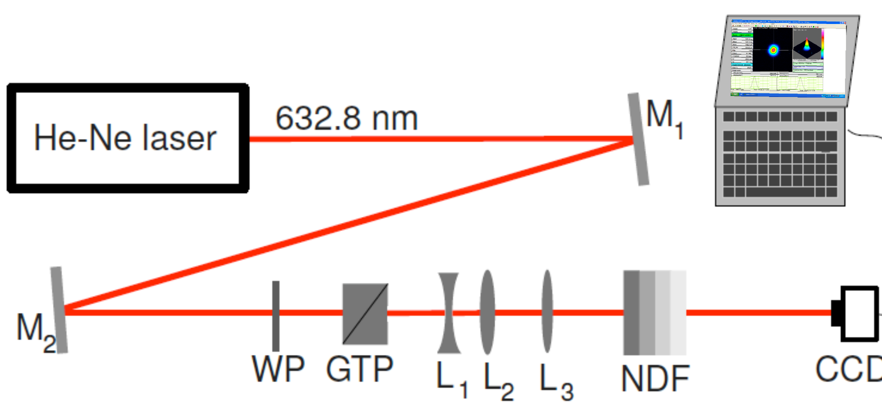
Apply a state of the art technique to measure the laser beam propagation factor M^2 of a He-Ne laser in order to calculate the remaining beam propagation parameters with high accuracy.

Method

Determination of M^2 is accomplished by measuring the laser beam diameter in a number of locations in the vicinity of the beam waist, which is produced by a converging lens. Analytical ray tracing is then used to calculate the laser beam propagation parameters.

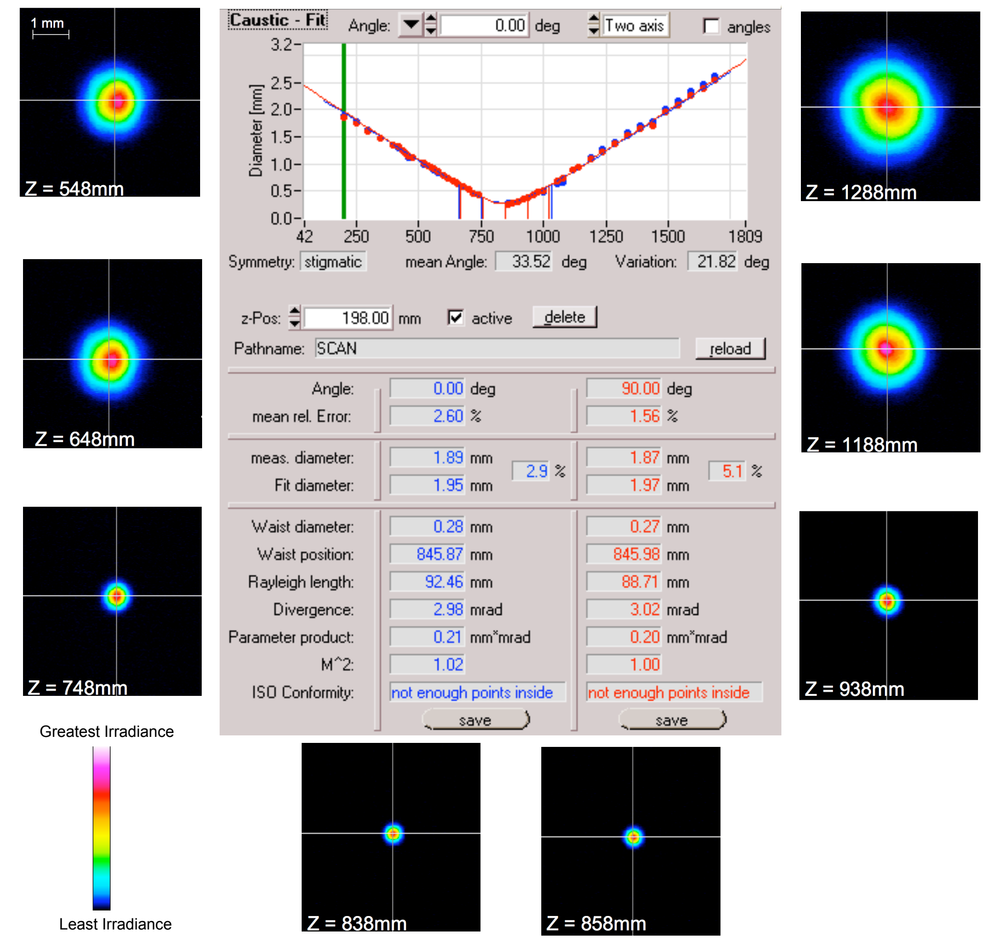
Experimental arrangement





Experimental setup. M_1, M_2: turning mirrors for fine alignment, WP: half-wave plate, GTP: Glan-Thompson polarizer, L_1 and L_2: beam expander, L_3: converging lens, NDF: neutral density filters, CCD: laser beam imaging camera.

Measurement and data analysis



Conclusion

We measured $M^2 = 1$ which shows that the laser beam is an ideal Gaussian beam. Using this value we calculated the beam waist as 1.03 mm, located at 15 mm in front of the laser, Rayleigh range of 1.29 m, and beam divergence angle of 0.8 mrad. This is a very low divergence; at 1 km the beam diameter would be only 80 cm.