Numerical simulation of horizontal propagation steady-state thermal blooming effect on laser beam with different intensity distribution

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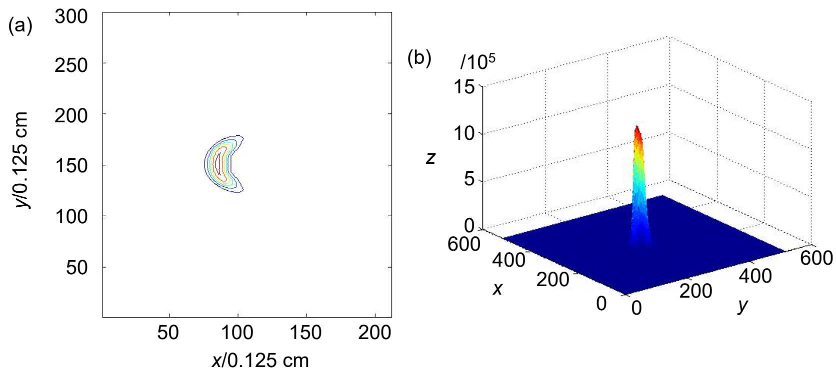

Three-dimensonal plots of intensity (a) and isointensity contours (b) for power is 1000 W Gaussian beam

Overview: With the development of laser technology, the laser plays an increasingly important role in military and civilian fields. A series of linear and nonlinear effects can be produced when laser propagated in the atmosphere. Among them, the thermal blooming is one of the important nonlinear effects. It also limits the power and brings adverse effects to many engineering applications of laser. Thermal blooming effect is a phenomenon that the atmospheric molecular and aerosol particles of atmosphere will absorb laser energy which accordingly causes heating expansion and the decrease of the local refractive index when laser propagates in atmosphere. Eventually, the energy of this laser beam will be reduced, the spot of this laser beam will be larger and the wave-front of this laser beam will be distorted. Thus, the study of propagation rules for laser beams through the atmosphere is of great significance for the effective application of the laser. In this paper equation for paraxial beams was deduced, which is foundation of numerical algorithms to solve thermal blooming problems. Bradley-Hermann thermal distortion parameter which is important to thermal blooming was given subsequently. The horizontal propagation steady-state thermal blooming effects of laser beams with different intensity distributions, such as Gaussian beam, flat-top beam, and flat-top beam with center obscuration, have been investigated by numerical simulation. The impacts of the output power, the propagation distance, the beam diameter, and the wind velocity vertical to the propagation direction on the steady-state thermal blooming have been discussed for the above mentioned three kinds of beams. Furthermore, the steady-state thermal blooming induced Strehl ratio degradation and peak intensity offset versus the generalized thermal distortion parameter N after long-path horizontal propagation of laser beams with above mentioned three types of intensity distributions have been derived. The simulation results show that, for certain other parameters, the greater output power or longer propagation distance will induce the stronger thermal blooming, and the increment of the launch diameter or the convection wind velocity vertical to the propagation direction will weaken the thermal blooming oppositely. Furthermore, for laser beams with different intensity distributions, the impacts of the thermal blooming on the propagation are so different. Under the same generalized thermal distortion parameter N, the thermal blooming effect on the Gaussian beam is the most serious, followed by the flat-top beam, and flat-top beam with center obscuration is the smallest. This research work can provide somewhat guidance for the engineering application of lasers.

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