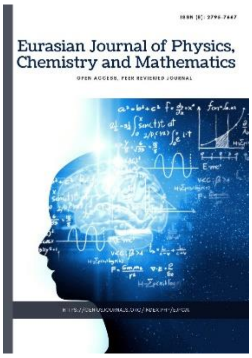

The Intensity Profile Of Optical Laser Beam In A Linear Medium

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ABSTRACT

The work examines the laser beam and its parameters. The optical Kerr effect is also discussed. The refractive index of a material depends on the electric field strength. A laser beam, described as a Gaussian beam, has higher intensity at the center compared to the edges of the beam, so the refractive index increases at the center of the beam. However, the intensity of the laser field gradually decreases along the edge of the beam, resulting in a decrease in the refractive index at the edge of the beam. This phenomenon causes self-focusing of the beam in a nonlinear medium. The article examines the parameters of a Gaussian beam and the origin of the optical Kerr effect.

Keywords: *Gaussian laser beam, nonlinear optics, Kerr effect, high energy laser field, refractive index, nonlinear refractive index.*

Introduction

In laser physics, a laser beam is electromagnetic radiation, and the amplitude of the electric field of the radiation is described by the Gaussian function. Laser beams are usually described as a Gaussian beam. The divergence of the Gaussian beam is small, and the paraxial beam can be solved by approximation. This approximation causes the Gaussian beam to remain Gaussian in free space. Gaussian beams have high beam quality and have special properties. For example, they remain Gaussian when passed through the optical elements and there is no beam distortion. And the beam parameters do not change after passing through the optical element [1]. The response of Gaussian beam interaction with materials has been studied by several researchers [2-4]. The squared electric field amplitude (E) corresponds to the intensity (I) laser beam, which induces a refractive index. This phenomenon is known as the Kerr effect. It plays an important role in nonlinear optics. It causes self-focusing in a medium and has applications in generating short laser pulses. The optical Kerr effect can find application in wide areas, including the spectroscopy of liquids [5] and the design of waveguides with different refractive indexes [6]. It can also find application in electro-optical devices [7]. The intensity of a Gaussian beam is higher at the center of the beam and gradually decreases towards the edge of the beam. A laser beam passing through a nonlinear medium is more focused at the center of the beam than at the edge of the beam because the intensity of the optical beam is higher at the center of the beam, causing a change in the nonlinear refractive index.

II. Description Of Laser Beam Parameters

Maxwell's equations in free space are described in the form of an equation called the Helmholtz equation

$$(\nabla^2 + k^2)E = 0. \tag{1}$$

where E is the amplitude of the electric field, k = nm/s. The field amplitude can be described as the propagation of the field along the z direction and can be written as [11]

$$E = ue^{-ikz} \tag{2}$$

where u is the change in field during propagation. The amplitude u changes slowly with the propagation direction, and the wave front is perpendicular to the propagation direction If we put equation (2) into equation (1), it becomes to Helmholtz equation

$$\left(\nabla^2 - 2ik\frac{\partial}{\partial z}\right)u = 0. \tag{3}$$

Equation (3) is called the paraxial wave equation and is described here as

$$\Delta^2 = \frac{\partial^2}{\partial z^2} + \frac{\partial^2}{\partial y^2} + .$$

The paraxial wave equation can be solved in cylindrical coordinates and the fundamental mode is Gaussian the beam can be written as [7]

$$E(x,y,z) = E_0\frac{w}{w_0}\exp\left[-\frac{(x^2+y^2)}{w(z)^2} - i\left\{kz + \frac{k}{2R}(x^2+y^2) - \psi(z)\right\}\right], \tag{4}$$

The above equations are used to determine the properties of a Gaussian beam. Optical field intensity

$$I(r) = |E(r)|^2,$$

and the intensity I is a function of the axial and radial distance *z* and $r^2 = x^2 + y^2$. Then the intensity of the Gaussian beam is given as

$$I = I_0\left[\frac{w_0}{w(z)}\right]^2\exp\left(-\frac{2r^2}{w^2(z)}\right). \tag{5}$$

For value Z intensity is a Gaussian function. The Gaussian function has a maximum value at $r = 0$, and this decreases monotonically with increasing $r = 0$, as in figures below.

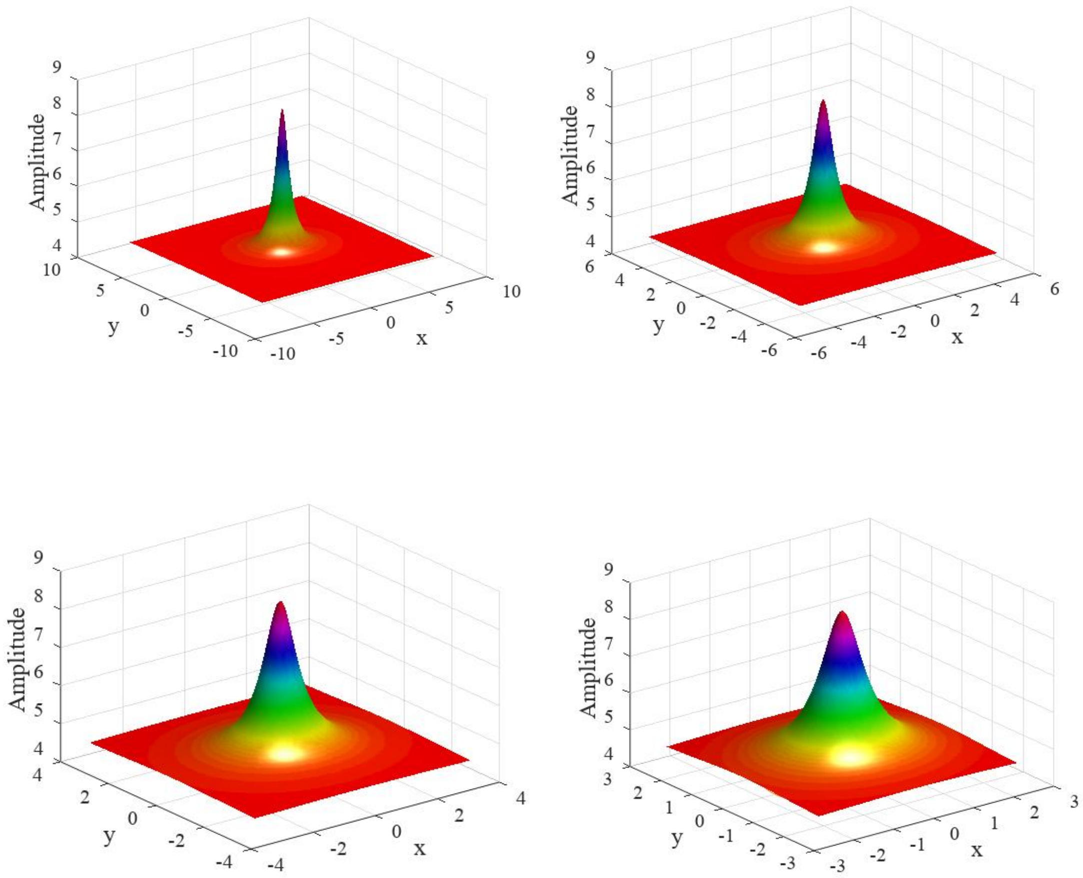

Figure 1. Theoretical demonstration of the intensity of Gaussian beam profile

Thus, the contribution of the refractive index of the material is higher at the center of the beam due to the optical Kerr effect. The modified refractive index behaves like a lens, resulting in self-focusing of the beam. Figure 1 shows that a beam passing through a nonlinear material is self-focused due to a change in the refractive index along the material. The refractive index does not depend on the light intensity at low optical power, but an increase in the optical field strength leads to the fact that the nonlinear refractive index begins to depend on the electric field strength. The intensity of a Gaussian beam is higher at the center of the beam, so the change in refractive index causes the beam to self-focus.

Conclusion

The interaction of a laser with matter leads to various kinds of electro-optical effects if the response of the medium is a nonlinear function of the applied electric field. The Gaussian wave equation is derived and laser parameters are discussed. The nonlinear optical Kerr effect is analyzed. The response of the medium at high field strengths leads to self-focusing of the beam. It has important properties for explaining nonlinear effects. The Kerr effect is a nonlinear distortion of an electron in a material due to high optical power. Self-focusing is an important effect for laser technology, since modification of the laser beam must be taken into account. Additionally, higher intensities damage the material, so material intensity thresholds must be checked. The refractive index of the beam is higher than the outside of the beam, so the beam is self-focused . Gaussian beam and optical Kerr effect have many applications and are carried out in many areas of research, especially in photonics devices

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