# PROPAGATION OF A GAUSSIAN LASER BEAM WITH ELLIPTICAL CROSS-SECTION THROUGH A MEDIUM IN THE PRESENCE OF A STANDING ACOUSTIC WAVE

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Application of laser Doppler anemometry (LDA) [1] to determine parameters of an acoustic field in liquid requires the analysis of laser beam distortions that occur in a medium in the presence of an acoustic wave. In [2-3] the phase distortions of an optical field in LDA are investigated that may be observed when two coherent laser beams intersect and create interference fringes at the point of interest. The distortions of the envelope of the laser beam intensity in the presence of a traveling acoustic wave were considered in [4].

In the present paper the effect of refractive index variations due to a standing acoustic wave on the Gaussian laser beam of an elliptical cross-section will be investigated. The effects related to the spatial boundedness of the beam are studied, i.e. distortions of the complex amplitude of the beam resulting from interference of spatial spectrum components are analyzed. The long propagation distances of the laser beam or high sound frequencies are under consideration.

To solve the problem, we represent a beam field as a spatial spectrum and describe propagation of each spectral component in the inhomogeneous medium in the approximation of geometrical optics using methods of eikonal and amplitude perturbation. At the observation point, the optical field represents a superposition of partial waves whose interference (with allowance for the perturbations) gives rise to laser beam amplitude and phase distortions. Using the concept of geometrical-optics rays for partial waves, we impose the corresponding limitation on the distance that the laser beam travels in the medium.

Analytical expressions describing distortions of the complex amplitude of a laser beam propagating in a medium with a weak perturbation of the refractive index caused by an acoustic wave are derived. A distinctive feature of the expressions for the optical field is that they are written in the same form for a wide range of ratios of the acoustic wavelength to the beam radius. This ratio only affects the character of field distortions. Using the example of a Gaussian beam with an elliptical cross-section, we analyzed distortions of this beam in the presence of a standing acoustic wave and demonstrated that for the acoustic wavelength less than the beam radius the results obtained correspond to the Raman - Nath solution. For the beam radius less than the acoustic wavelength, the results coincide with the solution to the refraction problem. Based on the latter fact, we interpreted the refractive displacement of the beam envelope at a given distance as a particular case of amplitude distortion. The formulas derived reveal common roots of refraction and diffraction effects. Thus, the expressions obtained make it possible to study an intermediate scenario when the beam radius is approximately equal to the acoustic wavelength.

In addition, using the perturbation method, we have found an explicit expression for ray trajectories in a weakly heterogeneous medium whose refractive index is modulated by a standing acoustic wave and, based on the transport equation, we have taken bulk effects into account.

The practical value of the results obtained lies in the possibility of estimating the error in local parameters of acoustic fields measured using optical methods and determining the applicability limits of these methods. In addition, the phase and amplitude of optical radiation which has passed through a weakly heterogeneous medium are functions of its integral parameters. Therefore, analytical expressions for the beam field serve as a basis for solving the inverse problem and enable one to develop integral methods for laser diagnostics of acoustic fields. The results of calculation of the

Gaussian laser beam intensity in the presence of the acoustic wave are shown in Fig. 1. The results obtained are the simulation of the quantitative visualization of an acoustic field as a phase object [5].

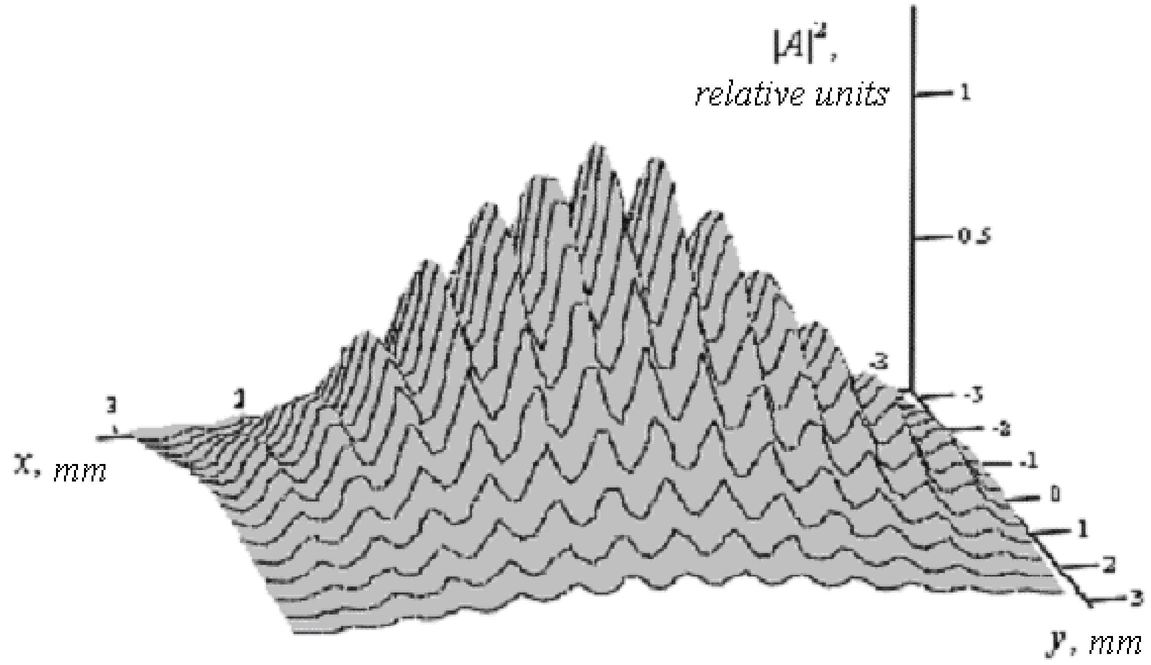


Fig. 1. The envelope of the Gaussian laser beam intensity in the presence of the acoustic wave for the acoustic wavelength less than the beam radius


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