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A LENGTH OF FILAMENTATION IN AIR UNDER THE CHANGE OF THE POWER AND THE INITIAL RADIUS OF POWERFUL FEMTOSECOND LASER RADIATION

The results of numerical experiments on filamentation of powerful femtosecond laser radiation are presented when the initial parameters of a collimated Gaussian beam, such as the initial radius and power change. The values of the parameters of the beam, for which increasing of the radius doesn't lead to increasing the length of filamentation when initial power is a constant, were found

Keywords: *femtosecond laser pulses, filamentation.*

Introduction

Using powerful femtosecond laser pulses is a perspective direction for atmospheric research. At present time in the world the propagation of powerful femtosecond laser pulses in the atmosphere is widely investigated.

The characteristic of the propagation of such pulses in gases and liquid media is their filamentation, when the mean value of the intensity keeps constant in distance. Areas with abnormally high values of intensity is localized in the form of a single filament (single filamentation) or set of filaments (multiple filamentation).

When controlling the parameters of powerful laser radiation it is possible: to carry out multicomponent and multichannel sounding of atmosphere [1]; to ensure delivery of energy of radiation in the set place on limited distances [2]; to stimulate the discharge of a storm cloud, using electric properties of the created extended ionized channel [3].

The goal of my work is to analyze a possibility of creation of filaments in air under the change of the power and the initial radius of powerful femtosecond laser radiation.

Method and Results

As a mathematical framework for modeling propagation of the ultrashort laser radiation in a transparent medium is used the conventional formalism of the nonlinear Schrodinger equation (NSE) is used. At numerical calculations the wavelength of laser radiation λ_0 was 800 nm, duration of a pulse t_p was 100 fs, critical power of self-focusing of radiation P_c was equal to 3,2 GW. For finding a length of filamentation a concentration of free electrons N_e on an axis of a laser beam along a propagation distance was calculated. Accordingly the length of filamentation was determined as an extent of a field on which the plasma density exceeded the level 10^{19} m^{-3}.

In earlier study [4], we investigated the dependence of the coordinates of the start of the filament and the length on the initial peak power of the laser beam radius R_0 = 1 mm, and its focus in the air for an axicon and a parabolic lens. On the basis of this research the relations to calculate of the length of the filamentation L_f / L_r, depending on the power P and the focal length F/L_r parabolic lens and the axicon were obtained. In trying to generalize the earlier law for beams with different radius there were the difficulties connected with instability of the solution, which is illustrated in Fig. 1.

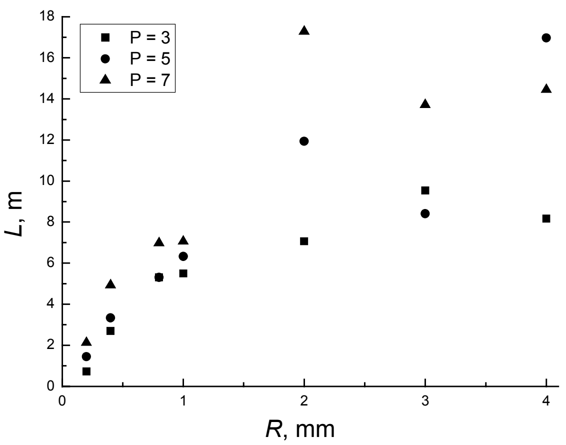

Fig. 1. Dependence of the length of filamentation on radius of the laser beam for radiation of different power.

By increasing the initial radius of beam R_0 the length of the filamentation increases monotonically, but only for small values of the initial radius, i.e. R_0 < 3 mm. The reason for increasing length of filamentation is that at increasing effective radius there is strengthening input rays in the nonlinear focus and, consequently, their output from focus. In turn it leads to increase of digitization effect and to removal of areas with the maximum plasma density from each other. The increase of distance between the positions of areas with the maximum plasma density can not be infinite, and to achieve a certain propagation distance, the last refocusing can not happen. Consequently with some value of radius filaments abruptly becomes shorter, as shown in Fig. 2.

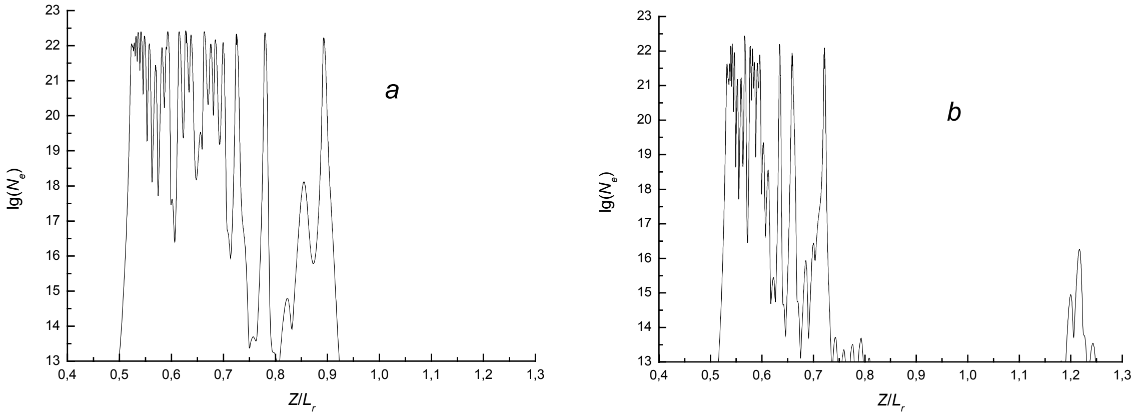

Fig. 2. The concentration of free electrons on an axis of a laser beam power P_0 / P_c = 3, and the radius R_0 = 3 mm (*a*) and 4 mm (*b*).

Conclusion

Thus, it is possible to allocate values of radius and power of the light beam, a small change which will cause large changes in the solution, i.e. instability. For sustainable solutions approximation formulas can be obtained for the dependence of the length of filamentation from initial parameters of laser radiation, but they are valid only for a limited class of bunches.

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