Analysis of interferograms of small scale PLASMA objects by the method of smooth perturbations

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The distribution of the electron density over the plasma object is an important parameter, characterizing its evolution. The distribution of the electron density can be obtained from the spatial distribution of the dielectric constant, which is found by analyzing the phase shift of the bands on the interferograms. Therefore, the distribution of the electron density of plasma objects can be found by solving the Helmholtz equation with a variable coefficient about the propagation of an electromagnetic wave in a medium with a variable dielectric constant. This equation is unsolvable analytically, therefore in our work we use the numerical method of smooth perturbations [1, 2], which describes the propagation of an electromagnetic wave in nonhomogeneous media in the parabolic approximation of equation.

Verification of the algorithm is carried out by a sequential solution of the direct and inverse problem, and by comparing the results obtained with the original data. To evaluate the possible effect of defocusing of the optical system on the interference pattern, which in the case of micron size objects can be significant, an analysis of the test lines of the shift of the interference fringe is carried out. It is shown that for objects with cylindrical symmetry of ~ 20 μm in diameter, when defocusing is less than 100 μm, this method can reconstruct the electron density distribution with an error of no more than ~ 30% for large density gradients, and with smooth distributions the error is much less. The requirements for the original data of the algorithm are obtained, which must be fulfilled when the experimental phase picture is pre-processed. The results of the analysis of interferograms obtained in the study of near-electrode plasma at the early stage of the development of a nanosecond discharge in air are presented.

References

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