RaDIAL Adiabatic expansion of the laser-heated cylindrical target plasma

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At present, the generation of ions in a plasma created by a powerful laser pulse is of interest for such applications as the creation of compact radiation sources with a record density of secondary particle fluxes based on laser-induced nuclear reactions, radiation medicine and nuclear pharmacology, radiography, fast ignition for laser thermonuclear synthesis, etc.

Among all possible laser schemes for particle acceleration, we note the schemes corresponding to the expansion of cylindrical plasma formations. A natural implementation of such a scheme is the radial expansion of a heated laser-plasma channel, which arises in the caustic of a focused laser beam or during its self-focusing, and expansion of cylindrical nanotubes irradiated by laser radiation.

This report analyzes the analytical solution of the kinetic equations for the distribution functions of electrons and plasma ions in the adiabatic expansion model of a cylindrical plasma [1, 2]. On the basis of a group of symmetries of a special type, invariant-group analytical solutions of the initial problem for the kinetic equations of plasma particles are constructed. In particular, the case of plasma with initial Maxwell velocity functions of particles is analyzed in detail. A typical experimental situation was studied when there is a heavy (dominant) ionic component, and, moreover, an impurity light component, and the electron distribution function, besides the main component, has a hot component, the presence of which determines the maximum energy of impurity ions. The integral characteristics of ion acceleration, including the distribution of densities and particle fluxes, as well as their energy spectra, are obtained. The peculiarity of the curves defining the spectra of light impurity ions is that they are close to a piece-linear shape and are characterized by the presence of several slopes, which corresponds to the dominance of a particular group of particles. The developed model was used to interpret the spectral distribution of highly charged oxygen ions accelerated from cylindrical microplasma, namely cluster gas, under conditions of low laser radiation contrast, when the clusters are almost completely destroyed before the arrival of the main pulse [3].

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References

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