Nonlinear interaction of microwave radiation with plasma flow under conditions of the Upper hybrid resonance

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Resonant discharges supported by strong microwaves in a mirror magnetic trap have a wide range of applications from generation of multiply charged ions for modern accelerators to development of a source of the extreme ultraviolet radiation for the high-resolution projection lithography [1–5]. For the studies of these discharges a theoretical description of the inhomogeneous flow of nonequilibrium plasma of multiply charged ions propagating along the axis of a mirror trap is required. Such a theory has been developed by the authors in [6, 7] where the model is proposed that gives an opportunity to analyze the fluid characteristics of multiply charged plasma flow with a varying cross section under the condition of the electron temperature significantly exceeding the ion temperature, and to find energy losses due to electron impact ionization and excitation of the ions. However, as a result of the resonant amplification of rf field supporting the plasma, the averaged ponderomotive force related to this field and acting on the plasma electrons can significantly influence the plasma parameters. In turn, the local electric field inside the flow itself depends on the parameters of the plasma. This effect of mutual influence of the field and the flow is not considered in [6, 7], but it seems to be significant for applications.

In the present paper, we describe theoretically the nonlinear interaction of a high-frequency electric field a stationary quasi-one-dimensional plasma flow guided by an external magnetic field. The proposed model allows us to determine the conditions of the resonance between the plasma object and the field (corresponding to the modification of the upper hybrid resonance of cold plasma), classify the possible stationary plasma flows, and identify typical dependences of the power absorbed by the plasma in the nonlinear regime.

The work is supported by the Russian Foundation for Basic Research (Projects No. 17-02-00173 and No. 18-32-00419). I. S. Abramov acknowledges personal support from the Foundation for the Advancement of Theoretical Physics and Mathematics “BASIS” (Project No. 18-1-5-12-1).

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