a model of self-similar radiative transfer in resonance lines for testing the edge plasma codes

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The representation of kinetic equations in the self-similar variables allows one to obtain analytic solutions, which may be very helpful for testing the respective blocks of numerical codes for transport phenomena. The examples include the steady-state collisional kinetic equations for electrons [1] and neutral atoms [2] in a strongly inhomogeneous plasma. Here, self-similarity appears to be applicable to the nonlocal (non-diffusive) correlations of the distribution function, that includes the cases of superthermal electrons [1] and fast neutrals produced by the charge exchange [2]. Another type of self-similarity was found [3] for the non-steady-state Biberman-Holstein (B-H) equation for radiative transfer in resonance atomic/ionic lines in a homogeneous medium. Here again the self-similarity is expressed in terms of characteristics of nonlocality of the B-H radiative transfer.

In this paper, we extend the approach [1, 2] to the case of the steady-state Biberman-Holstein equation in an inhomogeneous plasma slab. We consider one-dimensional transfer in a slab of the thickness *L* (the one-dimensionality means that only the radiation emission of photons across to slab’s borders is considered). Such a simplified problem will allow us to estimate the very possibility of existence of self-similar analytical solutions. It is shown that for a broad class of the similar spatial profiles of three characteristics, namely, the background plasma density, the line shape width and the non-radiation source of atomic excitation, the profile of excited atoms density may be described analytically in terms of the similarity of the above-mentioned profiles. The revealed cases of analytical solutions are suggested for testing the radiative transfer codes in edge plasmas, including the codes for radiative transfer in a background plasma and for radiation losses by an impurity in plasmas.

References

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