SUPERDIFFUSIVE TRANSPORT IN PLASMA FOR A FINITE VELOCITY OF CARRIERS: GENERAL SOLUTION AND THE PROBLEM OF AUTOMODEL SOLUTIONS

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The analysis of the Green's function of the non-stationary Biberman-Holstein equation for radiative transfer in plasmas and gases has shown [1] that there is an approximate automodel solution based on three scaling laws: for the propagation front and asymptotic solutions far beyond and far ahead of the propagation front. All these scaling laws are determined essentially by the long-free-path carriers (named Lévy flights). The validity of the suggested automodel solution was proved by its comparison with analytical solutions in the 3D case of the Biberman–Holstein equation of the resonance radiation transfer for various spectral line shapes (Doppler, Lorentz, Voigt and Holtsmark) with complete redistribution over frequency in the elementary act of the resonance scattering of the photon by an atom/ion. Scaling laws of Biberman-Holstein equation Green's function and the implications for algorithms of numerical modeling of superdiffusive transport are considered in [2]. The results of accuracy analysis of automodel solutions for Lévy flight-based transport, including the resonance radiative transfer and a simple general model, are reported in [3].

Here, we generalize the method [1] of approximate automodel solutions of the 1D transport equation with a model, power-law step-length probability distribution function (PDF) to the case of a finite velocity of the carriers (e.g., photons in space plasmas). First, we derive general solution. Further, the analytic results for the asymptotics far ahead and far beyond the perturbation front are derived. And finally, an approximate automodel solution based on the above asymptotics is suggested, and its accuracy is analyzed via comparison with exact numerical solution. The method is of interest for a broad range of superdiffusive transport problems in physics and beyond.

References

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