NUMERICAL SIMULATIONS OF COMPLEX NONEQUILIBRIUM FLOWS IN FINITE REGIONS ON THE BASIS OF THE BOLTZMANN KINETIC EQUATION

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Direct methods for solving the Boltzmann and other kinetic equations [1] are used for studying new nonequilibrium flows in the boundary steady problems. For different problems with nonequilibrium boundary conditions (see [2, 3]) nonclassical transport in flows appears (this effect for the first time has been described in [4]). In particular, heat can be transferred from the region with the lesser temperature to the region with the greater temperature. Now we consider a problem with "membrane-like" boundary conditions. In the simplest case particles leaving the region under consideration do not collide with particles entering this region. For such a situation even equilibrium distributions for the boundary conditions can lead to nonclassical anomalous transport mentioned above due to complex interaction of the opposite directed flows. In a more complex situation a part of gas can be reflected from the membrane molecules with the diffuse condition. Numerical solutions with the use of hybrid schemes combining discrete velocity method for kinetic equations and Lattice Boltzmann Model are obtained. For this problem analytical approximations of the expansion in the inverse Knudsen number confirm these effects. Possible experimental tests are discussed. For these purposes mixed cellulose ester (MCE) membranes could be used as a material for the boundaries. As reported in [5], a pore-size of these membranes is 25 nm, so the appropriate Knudsen number is more than unity at the atmospheric pressure. This problem for a mixture of chemical reactions with the kinetic model equations [6, 7] is also solved. We have used these equations in study of nonequilibrium structures in the nonuniform relaxation problem [8] and now also apply them for investigation of complex structures of the mentioned problem.

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