Lattice based computational approaches for nonequilibrium flows

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In order to address computational challenges due to nonequilibrium flow behavior, we present efficient computational approaches for solution of the corresponding Boltzmann equation, including the full collision operator, using a lattice framework. Our detailed treatment of the full collision operator not only ensures that important symmetries of the full collision operator are preserved, but also allows for correct representation of the structure of evolution of selected generalized moments of the distribution. It can be shown that the contributions to the evolution of generalized moments due to the collision operator can be reduced to a summation of elementary integrals, which can be analytically evaluated. We consider both fixed and adaptive lattices to demonstrate the mathematical formulation and computational performance of our approaches for single- and multi-phase flows, including those with phase transitions. Results obtained from our approaches are found to be in good agreement with those obtained from other complementary approaches.