A kinetic model for gas mixtures based on a Fokker–Planck equation

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Abstract

We present a generalized nonlinear Fokker–Planck equation, which describes the dynamics of rarefied monatomic gas mixture flows. The devised kinetic model leads to correct transfer of energy and momentum between gas species and to consistent evolution of molecular stresses and heat fluxes with respect to the generalized Boltzmann equation. Thus, the correct diffusion coefficient together with the mixture viscosity and mixture heat conductivity coefficients are obtained. The strength of the presented model lies on the computational efficiency, which is due to the fact that the resulting stochastic processes are continuous in time. Therefore, unlike in Direct Simulation Monte Carlo (DSMC), here simulated particles do not collide with each other, but move along independent continuous stochastic paths. Another aspect of the new Fokker–Planck model equation is that here the effect of collisions is described via drift and diffusion type processes. Accordingly, a scheme can be derived for which the time step size limitation of the corresponding numerical simulation becomes independent of the Knudsen number. Consequently, this leads to more efficient simulations, especially in low or intermediate Knudsen numbers. Results are presented for helium-argon mixture in a one imensional geometry. The calculated mixture viscosity is found to be in accordance with experimental data, which reveals the accuracy and relevance of the approach.