A relaxation kinetic model for transport phenomena in a reactive flow

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Abstract

A gaseous mixture of four constituents undergoing a reversible bimolecular reaction is modelled by means of a BGK-type equation in a flow regime close to chemical equilibrium. In the proposed relaxation method, elastic and chemistry collision terms are approximated separately, introducing different reference distribution functions which assure the correct balance laws. A Chapman-Enskog procedure is applied in order to provide explicitly the transport coefficients of diffusion, shear viscosity and thermal conductivity in dependence on elastic and reactive collision frequencies, mass concentrations of each species and temperature of the whole mixture. The closure of the balance equations is performed at the Navier-Stokes level and plane wave solutions are characterized. For the (H\textsubscript{2}, Cl, HCl, H) system, transport coefficients, as well as the Prandtl number of the mixture, are represented as functions of the temperature and compared with the inert case in order to discuss the influence of chemical reaction. Moreover, the thermal conductivity for non-diffusive and homogeneous mixtures are compared. For the problem of longitudinal wave propagation the phase velocity, attenuation coefficient and affinity are analyzed as functions of the wave frequency.