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A reduced model for compressible viscous heat-conducting multicomponent flows. (English)

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Summary: In the present paper we propose a reduced temperature non-equilibrium model for simulating multicomponent flows with inter-phase heat transfer, diffusion processes (including the viscosity and the heat conduction) and external energy sources. We derive three equivalent formulations for the proposed model. The first formulation consists of balance equations for partial densities, the mixture momentum, the mixture total energy, and phase volume fractions. The second formulation is symmetric and obtained by replacing the equations for the mixture total energy and volume fractions in the first formulation with balance equations for the phase total energy. Replacing one of the phase total energy equation of the second formulation with the mixture total energy equation gives the third formulation. All the three formulations assume velocity and pressure equilibrium across the material interface. These equivalent forms provide different physical perspectives and numerical conveniences. Temperature equilibration and continuity across the material interfaces are achieved with the instantaneous thermal relaxation. Temperature equilibrium is maintained during the heat conduction process. The proposed models are proved to respect the thermodynamical laws. For numerical solution, the model is split into a hyperbolic partial differential equation (PDE) system and parabolic PDE systems. The former is solved with the high-order Godunov finite volume method that ensures the pressure-velocity-temperature (PVT) equilibrium conduction. The parabolic PDEs are solved with both the implicit and the explicit locally iterative method (LIM) based on Chebyshev parameters. Numerical results are presented for several multicomponent flow problems with diffusion processes. Furthermore, we apply the proposed model to simulate the target ablation problem that is of significance to inertial confinement fusion. Comparisons with one-temperature models in literature demonstrate the ability to maintain the PVT property and superior convergence performance of the proposed model in solving multicomponent problems with diffusions.

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compressible multiphase flow; viscosity; heat conduction; Godunov method; Chebyshev locally iterative method

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