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Kelvin-Helmholtz shear instability with strong thermal nonequilibrium[1] MYOUNGKYU LEE, MICHAEL A. GALLIS, JACQUELINE H. CHEN, Sandia National Laboratories — The effect of strong thermal nonequilibrium on the Kelvin-Helmholtz (K-H) instability is studied with the Direct Simulation Monte Carlo (DSMC) method. Transport properties of gases vary with temperature and, in general, are a function of a single temperature, which assumes the translational, rotational, and vibrational energies are locally in equilibrium at macroscopic scales. The local equilibrium assumption is invalid when flows with K-H instability undergo certain conditions whereby the residence time is short compared to thermal relaxation time scales, for example, in reactive turbulent jet flows at high Mach number with strong temperature and/or velocity gradients. The DSMC method models the fluid flows using molecule-simulators, following the probability density functions for different energy modes. First, we demonstrate the validity of the DSMC method by simulating helium-argon flows undergoing K-H instability with DSMC and compare the result with solutions from continuum direct numerical simulation. Next, hydrogen and air are used as working fluids to introduce a strong thermal gradient and nonequilibrium. Finally, we analyze the energy transfer between length-scales as a function of the nonequilibrium ratio, e.g., $\phi_{vib} = 3T_{vib}/(T_{tr} + T_{rot} + T_{vib})$.

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