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A molecular dynamics simulation demonstrating the invalidity of the Navier-Stokes Fourier (NSF) equations for compressible gaseous continua at all Knudsen numbers HOWARD BRENNER, Massachusetts Institute of Technology, NISHANTH DONGARI, JASON REESE, University of Strathclyde — While it is well known to experimental gas kineticists and other fluid mechanicians that the NSF equations are invalid for noncontinua (rarefied gases) owing to Knudsen number effects, it is nevertheless universally believed that the NSF equations are valid for gaseous continua, namely when the Knudsen number is vanishingly small. This assumption is shown by molecular dynamics simulations to be wrong. This is demonstrated by performing simulations for monatomic gaseous continua undergoing steady-state rigid-body rotation relative to an inertial observer in a rigid circular cylinder that is thermodynamically isolated from its surroundings. The NSF equations, which are universally believed to govern the outcome of this elementary experiment, predict that the temperature will be uniform throughout the gas. In fact, the results of the simulation show that the temperature actually increases radially outward from the center of the cylinder to the wall by a significant amount, the greater the cylinder's angular velocity the greater the amount. Whereas the NSF paradigm fails to predict this nonisothermal radial temperature variation, the temperature distribution is shown to be accurately predicted by the recently proposed bivelocity hydrodynamic paradigm.

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