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On the 'piston effect' in a small-scale gap AVSHALOM MANELA, Department of Mathematics, MIT, Cambridge, MA, USA, NICOLAS HADJICONSTANTINOU, Department of Mechanical Engineering, MIT, Cambridge, MA, USA
— The 'piston effect', the time response of a fluid to a change in the thermal properties of its boundaries, is studied for a gas confined in a small-scale (of the order of the mean free path) gap and subject to an instantaneous jump in the temperature of its boundaries. The problem is formulated for a collisionless gas in the case where the relative temperature change at each wall is small and independent of the other. An analytic solution for the probability density function is obtained and the respective hydrodynamic fields are calculated. It is found that the characteristic time scale for arriving at the new equilibrium state is of the order of several acoustic time scales. The results are compared with direct Monte Carlo simulations of the Boltzmann equation and a good agreement is found for nondimensional times (scaled by the acoustic time) not exceeding the system Knudsen number. Thus, the present analysis describes the early-time behaviour of systems of arbitrary size and may provide the initial behaviour in the counterpart continuum-limit problem.

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