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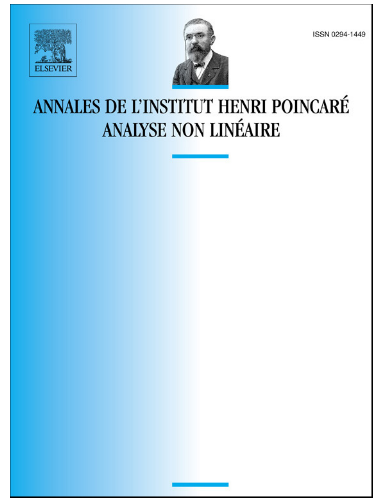

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Analysis of the adiabatic piston problem via methods of continuum mechanics

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Abstract

We consider a system modelling the motion of a piston in a cylinder filled by a viscous heat conducting gas. The piston is moving longitudinally without friction under the influence of the forces exerted by the gas. In addition, the piston is supposed to be thermally insulating (adiabatic piston). This fact raises several challenges which received a considerable attention, essentially in the statistical physics literature. We study the problem via the methods of continuum mechanics, specifically, the motion of the gas is described by means of the Navier-Stokes-Fourier system in one space dimension, coupled with Newton's second law governing the motion of the piston. We establish global in time existence of strong solutions and show that the system stabilizes to an equilibrium state for $t \to \infty$.

Keywords: piston problem, Navier-Stokes-Fourier system, free boundary problem.

1 Introduction and statement of the main results

The adiabatic piston problem received a considerable attention, namely in the statistical physics oriented literature, during the last two decades (see, for instance, Lieb [15], Gruber et al [10, 9, 11], Neishtadt and Sinai [19], Wright [26, 27, 28] and the references therein). This problem consists in studying the dynamics of a system composed of a gas in a cylindrical container with a piston which can move freely in the longitudinal direction. The piston and the exterior walls are supposed to be thermally insulating. Most of the above results are obtained using discrete models for the gas, meaning, the gas is supposed to be formed by a finite number of particles. Gruber [9] uses the kinetic approach, where the gas is modelled by a Boltzmann type equation. A fundamental question raised and discussed in these references is the large time behavior of the trajectories of the associated dynamical system. Making

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