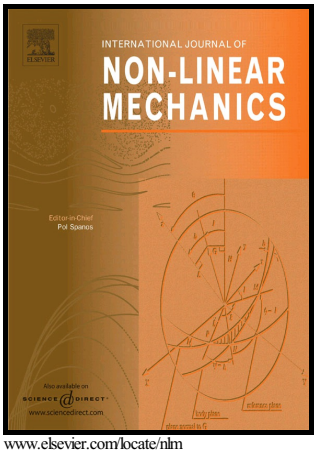

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Polyatomic gases with dynamic pressure: kinetic non-linear closure and the shock structure

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Abstract

This paper is concerned with the analysis of polyatomic gases within the framework of kinetic theory. Internal degrees of freedom are modeled using a single continuous variable corresponding to the molecular internal energy. The state of the gas is determined by the 6 fields—5 standard fields (mass density, velocity and temperature) and the dynamic pressure. Using the maximum entropy principle and the non-equilibrium entropy density, it is shown that dynamic pressure appears as a natural measure for deviation from equilibrium state. A proper collision cross section is constructed which obeys the micro-reversibility requirement. The non-linear source term in the balance law for dynamic pressure, and the entropy production rate, are determined using collision operator in the form which generalizes the known results obtained within the framework of extended thermodynamics. They are also compared with the results obtained using BGK approximation. For the proposed model the shock structure problem is thoroughly analyzed and discussed for different values of the parameters in the source term.

Keywords:
Polyatomic gases, Dynamic pressure, Shock structure, Kinetic theory of gases
2010 MSC: 76P05, 82C40, 82D05, 76L05

1. Introduction

Non-equilibrium processes in polyatomic gases are peculiar since there appears dynamic pressure as an excess normal pressure added to standard thermodynamic pressure. Moreover, experiments showed that the influence of dynamic pressure on transport processes prevails the influence of shear stresses and heat flux. Therefore, a proper description of behaviour of the polyatomic gases, and dynamic pressure, is needed in continuum and kinetic theories alike.

Classical continuum theory used the model of Newtonian fluid which related the dynamic pressure to bulk viscosity and compressibility of the medium. As it is well known, such consti-

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