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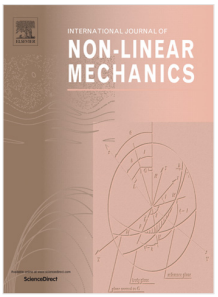

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ACCEPTED MANUSCRIPT

On the sub-shock formation in extended thermodynamics

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Abstract

In hyperbolic dissipative systems, the solution of the shock structure is not always continuous and a discontinuous part (sub-shock) appears when the velocity of the shock wave is greater than a critical value. In principle, the sub-shock may occur when the shock velocity s reaches one of the characteristic eigenvalues of the hyperbolic system. Nevertheless, Rational Extended Thermodynamics (ET) for a rarefied monatomic gas predicts the sub-shock formation only when s exceeds the maximum characteristic velocity of the system evaluated in the unperturbed state $\lambda_0^{\max}$. This fact agrees with a general theorem asserting that continuous shock structure cannot exist for $s > \lambda_0^{\max}$. In the present paper, first, the shock structure is numerically analyzed on the basis of ET for a rarefied polyatomic gas with 14 independent fields. It is shown that, also in this case, the shock structure is still continuous when s meets characteristic velocities except for the maximum one and therefore the sub-shock appears only when $s > \lambda_0^{\max}$. This example reinforces the conjecture that, the differential systems of ET theories have the special characteristics such that the sub-shock appears only for s greater than the unperturbed maximum characteristic velocity. However, in the second part of the paper, we construct a counterexample of this conjecture by using a simple 2×2 hyperbolic dissipative system which satisfies all requirements of ET. In contrast to previous results, we show the clear sub-shock formation with a slower shock velocity than the maximum unperturbed characteristic velocity.

Keywords: shock waves, extended thermodynamics, hyperbolic systems with relaxation, sub-shock formation

1. Introduction

Hyperbolic dissipative systems, which are sometimes called as hyperbolic systems with relaxation in the mathematical community, describe a large class of the physical systems and appear in many fields, in particular, in the field of non-equilibrium thermodynamics within the framework of so-called Rational Extended Thermodynamics (hereafter, for simplicity, referred to as ET, instead of RET) [1, 2]. In (parabolic or hyperbolic) dissipative systems, the shock wave is represented by a solution of the type of traveling waves that is called *shock structure* because it

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