Expansion of an isentropic gas into vacuum

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Abstract

Tai-Ping Liu (1996) introduced the notion of "physical solution" of the isentropic Euler system when the gas is surrounded by vacuum. This notion can be interpreted by saying that the front is driven by a force resulting from a Hölder singularity of the sound speed. We address the question of when this acceleration appears or when the front just move at constant velocity.
We know (Grassin 1998, Serre 1997) that smooth isentropic flows with a non-accelerated front exist globally in time, for suitable initial data. In even space dimension, these solutions may persist for all $t \in \mathbb{R}$; we say that they are *eternal*. We derive a sufficient condition in terms of the initial data, under which the boundary singularity must appear. As a consequence, we show that, in contrast to the even-dimensional case, eternal flows with a non-accelerated front don't exist in odd space dimension. Our argument is related to that of Milnor (1978) in his proof of the hairy ball Theorem.
In one space dimension, we give a refined definition of physical solutions. We show that for a shock-free flow, their asymptotics as both ends $t \to \pm\infty$ are intimately related to each other.

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