

Numerical results for a bidimensional stability analysis of detonation waves

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The role that instability plays in practical detonation-based propulsion is of primary importance and largely unexplored [1].

The modern theory of detonation stability started with Erpenbeck, in 1962 [2] with the study of the linear stability problem using the Nyquist winding theorem to develop a numerical procedure that, for a given set of parameters, would determine unstable solutions of the stability problem. Since then many authors, such as Lee and Stewart [3], dedicated part of their work to the study of this problem. They introduced a normal-mode approach and a numerical shooting method to develop a simpler and more efficient search for unstable solutions and obtained very interesting numerical results. The linear approach for the stability problem is an idealised situation. Notwithstanding it reflects some important features of more complex problems and serves as an useful guidance in many real world applications. In the hydrodynamic bidimensional stability study, a small transverse disturbance induces a rear boundary perturbation and there is a distortion on the shock wave location. Assuming that the instability of the detonation solution results uniquely from the interaction between the perturbed shock and the reaction zone, the stability problem consists in studying the evolution of the state variables disturbances in the reaction zone. It constitutes a step further in the study of the response over time, of a detonation wave to small rear boundary perturbations. This problem has been addressed by several researchers in works such as [1] and [4].

In 2015, the authors of the present study participated in a work (to be published in Proc. AIDAA 2015) which was the first theoretical attempt to do a bidimensional analysis of the instability spectrum of a detonation wave in an Eulerian mixture of ideal gases where the chemical rate law is derived from the reactive Boltzmann Equation. Here we present a more detailed and complete picture and explore numerically the introduction of the wave number in the stability analysis.

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