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Initial-value problem for stability of detonations rehabilitated

ANATOLI TUMIN, The University of Arizona — Erpenbeck (1962) formulated the hydrodynamic stability of detonations as an initial-value problem. Unfortunately, instead of directly solving the dispersion relation numerically, Erpenbeck used the principle of the argument utilizing both analytical and numerical approaches to establish the existence of the poles in the Laplace variable plane for the case of idealized one-reaction detonations (1964). The numerical implementation was so daunting that it is still believed that the method is "hard to implement and it does not give a computationally direct way to determine the stability boundaries or the dispersion relation that defines the unstable modes." As a result, the normal mode approach was suggested in 1990. In the present work, we revisited the stability problem of idealized one-reaction detonations, and showed that the spectrum of the normal mode approach is equivalent to the discrete spectrum stemming from Erpenbeck' s dispersion relation. The dispersion relation requires solving the homogeneous ODEs for the adjoint system (instead of inhomogeneous equations in the normal mode formulation), and evaluating an integral through the reaction zone. The solution of the initial-value problem also leads to a method of expansion of the perturbation field into modes of discrete and continuous spectra. In addition, it gives a convenient tool for getting the receptivity problem solution. It is necessary to explore the receptivity coefficients together with the conventional eigenvalue analysis in order to understand the flow dynamics.

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