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Initial-value problem for stability of detonations in a circular pipe

ANATOLI TUMIN, IVAN SHALAEV, The University of Arizona — Erpenbeck (1962) formulated the hydrodynamic stability of detonations as an initial-value problem for three-dimensional perturbations in an unbounded domain. In the present work, we address the initial-value problem for perturbations of idealized one-reaction detonations in a circular pipe. Using the Laplace transform with respect to time, Fourier series with respect to the azimuthal angle, and an expansion into Bessel's functions of the radial variable, the problem is reduced to an inhomogeneous system of ODEs with the axial coordinate as the independent variable. For each radial and azimuthal mode, the inverse Laplace transform can be presented as an expansion of the solution into the normal modes. The dispersion relation for the discrete spectrum 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 gives a convenient tool for getting the receptivity problem solution. Numerical examples illustrate that it is necessary to explore the receptivity coefficients together with the conventional eigenvalue analysis in order to understand the possible scenarios of the flow dynamics. It is shown that the radiation condition for perturbations at the end of the reaction zone is a trivial consequence of the adjoint solution's properties.

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