An Asymptotic-Preserving Scheme for Pipe Networks

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March 2025

We consider the simulation of isentropic flow in pipelines and pipe networks. Standard operating conditions in pipe networks suggest an emphasis to simulate low Mach and high friction regimes—however, the system is stiff in these regimes and conventional explicit approximation techniques prove quite costly and often impractical. To combat these inefficiencies, we develop a novel asymptotic-preserving scheme that is uniformly consistent and stable for all Mach regimes. The proposed method for a single pipeline follows the flux splitting suggested in Haack (2012) et al., in which the flux is separated into stiff and non-stiff portions then discretized in time using an implicit-explicit approach. To extend to full pipe networks, the scheme on a single pipeline is paired with coupling conditions defined at pipe-to-pipe intersections to ensure a mathematically well-posed problem. We show that the coupling conditions remain well-posed at the low Mach/high friction limit – which, when used to define the ghost cells of each pipeline, results in a method that is accurate across these intersections in all regimes. The proposed method is tested on several numerical examples and produces accurate, non-oscillatory results with run times independent of the Mach number.