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Improved parabolization of the compressible Euler equations
AARON TOWNE, TIM COLONIUS, Caltech — The parabolized stability equations (PSE) are a tool for rapid computation of convectively unstable flows. The efficiency of the method is achieved by solving the equations using a spatial marching technique in the downstream direction. Unfortunately, the PSE operator contains upstream propagating acoustic modes that cause instability in this march unless these waves are numerically damped. Existing damping techniques introduce additional error into the solution and in particular contaminate the acoustic mid- and far-field. We have developed a method to explicitly remove the upstream acoustic mode from the linearized Euler equations. The eigenvalue associated with the upstream mode is zeroed in Fourier-Laplace space, resulting in a non-local propagation equation after the transforms are inverted. The non-locality arises from terms involving the square root of the Fourier-Laplace variables. In order to recover local, real-space PDEs from the transformed equations, these terms are approximated using Pade-type rational approximation. The resulting equations are parabolic in the downstream direction and require no damping for a stable march. We will outline this method and present results that demonstrate its stability and accuracy for different approximations of the square root.

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