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Rayleigh-Taylor and Richtmyer-Meshkov aspects of interface deceleration mixing

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Resolved scale simulations using a 2-D (r-z) compressible multi-fluid Eulerian code with interface reconstruction are used to study the mixing layer produced in interfacial fluid deceleration. The fluid interfacial deceleration (normal to the interfacial plane) is driven by transient stagnating pressure as flow is reflected from an impenetrable boundary in planar geometry or at an axis of symmetry in cylindrical geometry. Several driver conditions are evaluated and the cylindrical convergent case is related to ICF experiments currently underway. For the cases driven with a shock at the outer boundary, R-M instability growth occurs at early times prior to any deceleration and agrees with the linear impulse model. The total R-M mixing over the duration of cylinder convergence prior to deceleration is insignificant compared to later time deceleration mixing. Results show deceleration mixing can be approximated with an initial rapid growth rate and a slower late time growth rate after the acoustic transit time when pressure gradient reversals occur in the fluids. Each growth rate is characterized by a power law in time with the exponent of the initial rapid mix growth proportional to the energy into the system, and ranging from less than 1 to over 10 in the cases studied. The exponent matches the R-T growth rate scaling ($\sim t^2$ for constant acceleration, g) only for a small energy into the system which is too small for significant convergence in the cylindrical system. The interface deceleration mix layer differs from classic R-T mix in several respects with growth rates varying in time, including phases of de-mixing and 'mode doubling' in some regimes, smaller scales and less vortical structures. An interfacial area $A_{12}(t)$, important in diffusive atomic mixing, is seen to grow faster in time than the mix layer width. The deceleration mix layer grows after the main acceleration peak has decayed to small values, and as such, interface deceleration mix more closely resembles R-M mix than R-T mix. We conclude with preliminary efforts to represent the mix layer growth dynamics and the evolution of the atomically mixed components simultaneously in an unresolved (sub-grid scale) simulation.