Linearized Richtmyer-Meshkov flow analysis for impulsively-accelerated incompressible solids

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The original Richtmyer-Meshkov problem describes the instability caused by the impact of a shock wave on the interface separating two fluids. This problem has been the subject of study in many fields, including astrophysical phenomena, magnetohydrodynamics and solid mechanics. In solids, semi-numerical prior investigations of a shock-driven, compressible elastic problem (Plohr & Plohr 2005) suggest that the interface amplitude remains bounded in time, in contrast to the unstable behavior found for gases.

We present an analytic study of the linearized impulsive Richtmyer-Meshkov flow for incompressible elastic solids. Our approach considers a base unperturbed flow and a linearization of the conservation equations around the base solution, reducing the parameters of the problem to two, namely the shear-wave velocity and the density ratio between the two materials. The resulting initial-boundary value problem is solved using Laplace transform techniques. Analysis of the singularities of the resultant function in the Laplace domain enables a parametric study of the behavior of the interface in time. We identify two differentiated long term patterns for the interface which depend on the material properties; standing wave and oscillating decay. These results contrast with previous numerical simulations which did not explore in depth the parametric space of the problem and considered only the standing wave result.

To obtain physical insight, we study the vorticity distribution. This analysis reveals that vorticity satisfies the second-order wave equation with velocity corresponding to that of the shear waves in each material. This shows that the shear stiffness of the solids is responsible both for the stabilization of the interface with shear waves carrying vorticity off the interface, and also for the period of the interface oscillations.

References

Plohr J. N. & Plohr B.J., *J. Fluid Mech.*, **537**, 55 (2005).