Analytic approach to nonlinear hydrodynamic instabilities driven by time-dependent accelerations

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We extend our earlier model for Rayleigh-Taylor and Richtmyer-Meshkov instabilities to the more general class of hydrodynamic instabilities driven by a time-dependent acceleration $g(t)$. Explicit analytic solutions for linear as well as nonlinear amplitudes are obtained for several $g(t)$'s by solving a Schrödinger-like equation $d^2\eta/dt^2 - g(t)kA\eta = 0$ where A is the Atwood number and k is the wavenumber of the perturbation amplitude $\eta(t)$. In our model a simple transformation $k \to k_L$ and $A \to A_L$ connects the linear to the nonlinear amplitudes: $\eta^{nonlinear}(k, A) \sim (1/k_L)\ln \eta^{linear}(k_L, A_L)$. The model is found to be in very good agreement with direct numerical simulations. Bubble amplitudes for a variety of accelerations are seen to scale with s defined by $s = \int \sqrt{g(t)}dt$, while spike amplitudes prefer scaling with displacement $\Delta x = \int [\int g(t)dt]dt$.

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.