Revised Froude number for Rayleigh-Taylor flow with secondary instabilities

Karthik Muthuraman¹, Praveen Ramaprabhu¹, 
Guy Dimonte² 
Paul Woodward³ 
Chris Fryer², Gabe Rockefeller² 
Y-N. Young⁴ 
Sung-Ik Sohn⁵

1. University of North Carolina, Charlotte, NC, USA
2. Los Alamos National Laboratory, Los Alamos, NM, USA
3. University of Minnesota, Minneapolis, MN, USA
4. New Jersey Institute of Technology, Newark, NJ, USA
5. Kangnung National University, South Korea

Recent simulations¹ and experiments² have shown the late-time Rayleigh-Taylor (RT) saturation velocity is sensitive to the appearance of secondary Kelvin-Helmholtz (KH) vortices. Specifically, RT bubbles experience a late surge due to the induced velocity of the KH vortices and saturate at a Froude number twice that predicted by potential flow models³. We describe this picture with a simple toy model that idealizes the KH rollups as a pair of point vortices, so that the total bubble velocity is given by

\[ V_b = \sqrt{\frac{2A g}{1 + A 3k} + \frac{\kappa}{r_{1,2}}} \]  

In the above, the first term is the classical potential flow velocity¹, while the second term represents the induced velocity due to the KH doublet (\( \kappa \) is the vortex strength, while \( r_{1,2} \) is the spacing between the vortices). From classical linear theory, the KH growth rates also depend on several parameters such as viscosity, surface tension, and density difference between the fluid streams. We have studied the influence of these parameters on the fundamental RT mode, and will discuss our findings. The late time RT reacceleration was presented as a test problem at the 11th IWPCTM, in Santa Fe, USA, and this talk will summarize the results from that collaboration.

References
Ramaprabhu, P. et al. 2006, Physical Review E. 74, 066308


Goncharov, V.N. 2002 Physical Review Letters 88, 1345021-1345024